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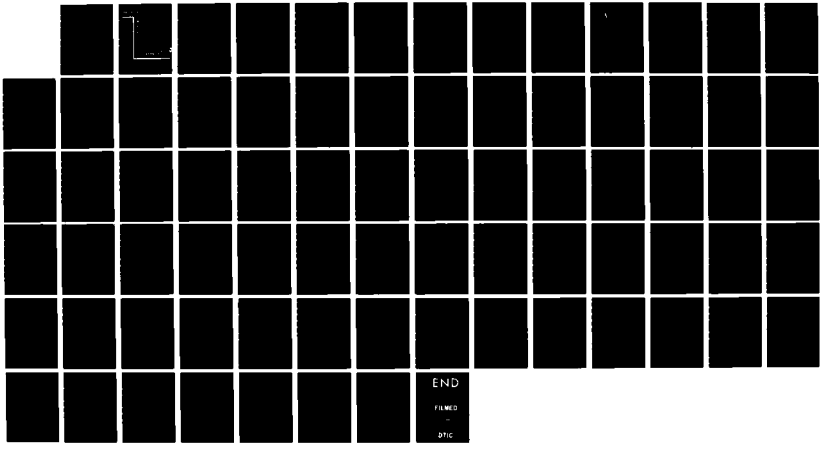

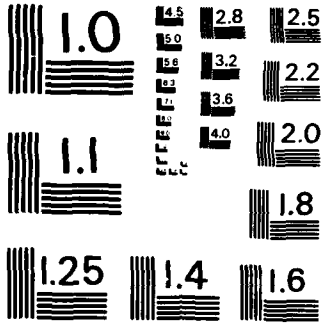

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FLIGHT SIMULATOR: EVALUATION OF SODERN VISUALIZATION SYSTEM SVS-14

Jost Peter Gerlicher

US/Federal Republic of Germany Scientist and Engineer Exchange Program Participant

OPERATIONS TRAINING DIVISION
Williams Air Force Base, Arizona 85240-6457

September 1985

Interim Technical Paper for Period June 1984 - December 1984

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

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This paper has been reviewed and is approved for publication.

MILTON E. WOOD, Technical Director
Operations Training Division

CARL D. ELIASON, Colonel, USAF
Chief, Operations Training Division

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Engineering and Human Factors Evaluation of the SODERN Visualization System SVS-14 have been performed both at the SODERN facility in France and at the Air Force Human Resources Laboratory (AFHRL), Williams AFB. Results of initial and final acceptance tests, and of other engineering as well as psychophysical evaluations, have been recorded and published in a number of test reports on completion of the individual test phases. This paper comprises a collection of all the test reports made available to AFHRL including summaries of the result analysis as conducted by both SODERN and the General Electric Company. Also covered in this paper are results of a human factors study and the analysis thereof.

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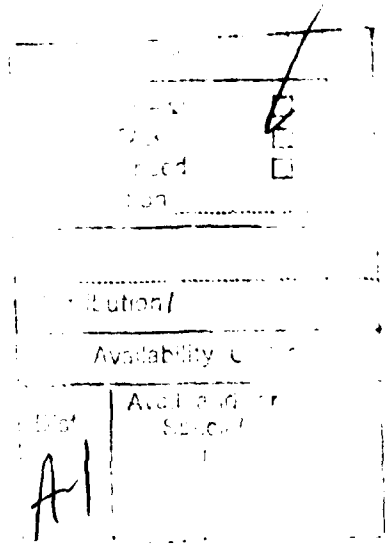
Reviewed and submitted for publication by

Harold E. Geltmacher
Chief, Technology Development Branch



This publication is primarily a working paper.
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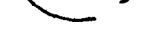

SUMMARY

A solid crystal color light valve display system (to be used on flight simulators) has been developed by SODERN of France for the General Electric Company (GE) under an Air Force Human Resources Laboratory (AFHRL) contract. At the completion of the development phase, a prototype projector, designated as SODERN Visualization System SVS-14, was manufactured. The equipment underwent a series of acceptance tests at the SODERN facility in France and final acceptance testing at AFHRL, Williams AFB. The analysis of the test results showed that the SVS-14 met all important specifications and in some areas even exceeded them.

Further experiments with the SVS-14 at AFHRL covered additional engineering evaluations and a human factors study. These tests consisted of a comparison demonstration between the SODERN SVS-14 and the GE PJ5155 projector. Ratings of the visual appearance of the imagery produced by the projectors on a side-by-side arrangement of rear projection screens were in favor of the GE system.

However, it was soon found that the performance of the SODERN projector had degraded due to malfunctions of system components. This was caused by a power supply failure that had not been detected prior to the comparison tests.

After extensive onsite repair efforts by SODERN personnel, the performance of the SVS-14 was again evaluated in a side-by-side comparison test with the PJ5155. The results indicated improvements in the quality of video imagery. The image persistence for fast moving objects was about equal for both projectors.

PREFACE

This paper was prepared to collect the records of the acceptance test results as presented by SODERN in their minutes of the contemporary meetings held at the site of testing in France and at the Operations Training Division of the Air Force Human Resources Laboratory (AFHRL/OT), Williams AFB, Arizona.

Detailed test analysis information was extracted from a visit report of Mr. R. F. Stone from the General Electric Company Simulation and Control System Department, Daytona Beach, Florida, covering the initial acceptance test phase at SODERN. An overview of the development background and valuable information on the final acceptance test was found in the R&D Status Report for the Advanced Visual Technology System (Project 2363). Mr. Jean Huriet, the North American Sales Manager for SODERN, contributed an appreciable amount of technical data and expertise to the contents of the report. The psychophysical inputs of Dr. Peter Crane from the University of Dayton Research Institute, on-site at Williams AFB, complemented the engineering data collection very effectively by introducing human factor aspects into the evaluation.

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FLIGHT SIMULATOR:
EVALUATION OF SODERN VISUALIZATION SYSTEM SVS-14

I. INTRODUCTION

The purpose of this paper is to summarize the evaluation of a solid crystal color display system that has been developed by SODERN, France, for the General Electric Company (GE) under an Air Force Human Resources Laboratory (AFHRL) contract. This new color display system, designated as SODERN Visualization System (SVS-14), was delivered to AFHRL in late July 1984. Acceptance tests have been conducted by both General Electric and the Air Force. Following successful acceptance testing and transfer of the equipment on 2 August 1984 to the Air Force, further tests were performed on 18 October 1984 and 4-6 December 1984 at AFHRL. These tests included a visual comparison evaluation between the SODERN SVS-14 display system and the General Electric Talaria color light valve projector system, and additional performance data collected to supplement the results of the acceptance testing.

II. DEVELOPMENT BACKGROUND

The development activity for a Color Light Valve Projector (CLVP) to be used in flight simulators started in 1978 and a competitive Component Development Phase (CDP) between Hughes and SODERN was completed in December 1980. The CDP effort continued with SODERN in 1981-82 when it became evident from breadboard tests and demonstrations that the SODERN Deuterated Potassium Di-Phosphate (DKDP) crystal technology (called TITUS in French) had more development potential as a new CLVP technology than did the Hughes Liquid Crystal Light Valve system. Subsequently, a hardware subcontract was negotiated with SODERN (placed in September 1982 and amended in January 1983) for the manufacture of a prototype CLVP system.

III. STRUCTURE AND OPERATION OF THE SODERN VISUALIZATION SYSTEM SVS-14

Design Features

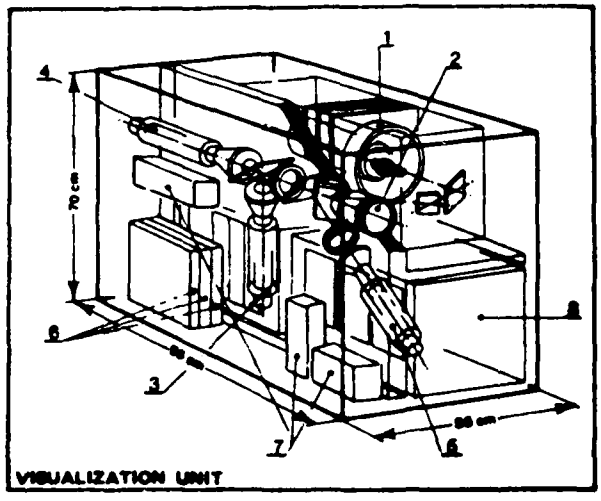
The SODERN Visualization System designated as SVS-14 was derived from the SVS-12 projector, previously supplied to the French Government (Figure 1). The SVS-14 differs from the SVS-12 primarily in the following features:

1. Square target 38 x 38 mm with rounded corners and 90^{0} field of view (FOV).

2. Greater luminance output of approximately 2500 lumens.

3. Built-in thermoelectric cell (Peltier) water cooler for the DKDP target.

4. Significantly higher resolution of 850 pixels per line at 10% system Modulation Transfer Function (MTF).



SVS 14

1 - illumination optics

2 - projection optics

3 - light valve red channel

4 - light valve green channel

5 - light valve blue channel

6 - scanning amplifiers

7 - video amplifiers

8 - low level electronics

SYSTEM COMPOSITION

- a vizualization unit SVS-UV
- an electronics bay SVS-BE
- a xenon arc power supply SVS-AX
- a remote adjustment unit SVS-PT

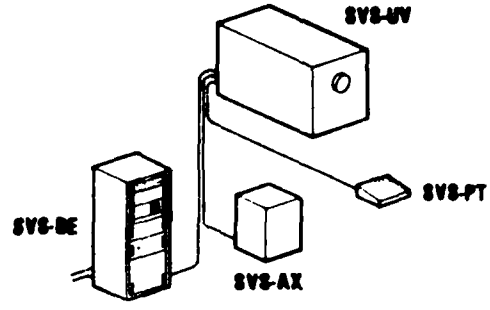


Figure 1. SODERN Visualization System SVS-14.

Unique Functions

The SODERN Visualization System has several unique characteristics in addition to higher brightness and high resolution.

1. The solid crystal of the light valve is capable of "storing" the video signal and operating as an analog memory for the image. This results in an image that is completely flicker-free and allows the image to be locally erased and rewritten.

2. The video provided on the solid crystal of the light valve is written by an electron beam working in a saturation mode. Therefore, a line structure due to scanning is not apparent.

3. The raster lines can be curved to compensate for optical distortion and for the projection of imagery onto curved or oblique screens.

Performance Characteristics

TITUS Light Valve. The heart of the SODERN Visualization System is the TITUS light valve (Figure 2). Its operation is based on the variation of birefringence in a solid crystal. This

double refraction property of the crystal comes into effect when an electrical field is applied through the crystal in the same direction that the light propagates.

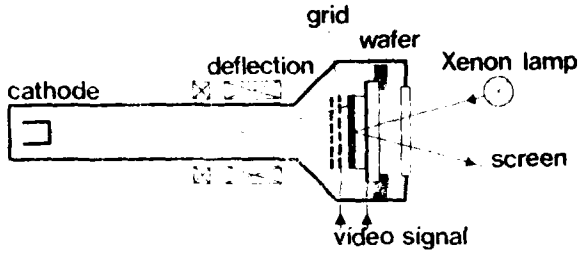


Figure 2. TITUS Light Valve Tube.

The incident polarized light beam passes through a wafer of crystalline DKDP. A scanning electric beam deposits on the rear face of the wafer an electrical charge, locally modulated by the video signal applied between the grid and the front face of the wafer. Due to the variation of birefringence in the crystal, the polarization of the reflected light varies according to the video signal.

Projector System. The SVS-14 projector comprises a xenon lamp (L) for emission of white light and TITUS light valves (G, R, B) for modulation of the three color components (Figure 3). The white light from the xenon lamp passes through a polarizing beam splitter (P).

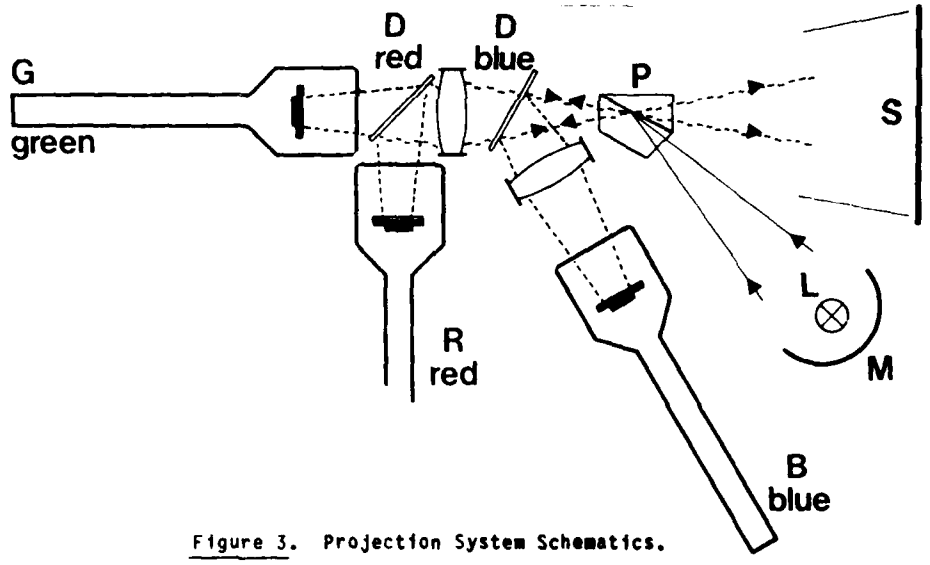


Figure 3. Projection System Schematics.

Dichroic mirrors (D) separate the polarized light beam into the three primary colors green, red, and blue. Each light valve modulates the polarization of the incident component beam and reflects it back along its original direction. The three components are reassembled by the dichroic mirrors into one beam, a fraction of which is transmitted by the polarizer (P) used as an analyzer. Projection optics focus the image onto a screen.

IV. EVALUATION ACHIEVEMENTS

Acceptance Testing at SODERN in France

Tests Performed. SVS-14 acceptance tests as per ATP were performed at the SODERN facility in France between 12-16 June 1984 under the direction of their Quality Assurance (QA) engineer.

Subsequently, the test data taken were submitted to General Electric Company for a preliminary engineering evaluation. Following the review of the test results, analysis, and documentation, it was decided to only repeat certain tests on a flat screen rather than to use the spherical screen as previously done by SODERN. Repeat acceptance tests and other tests of interest were conducted during 27-28 June 1984 at SODERN, using a large (approximately 8 x 8 feet) flat screen and an alternate narrower FOV projection lens provided by SODERN.

The special test that preceded the testing on critical performance parameters included a subjective evaluation of the degree of image smear as a function of the light valve beam current. A beam current of 40 to 50 microamps was the consensus opinion for an acceptable dynamic, fast-moving scene. SODERN had previously used about 70 microamps, but they advised that a lower beam current tended to improve the resolution slightly.

All the tests covering resolution (i.e., MTF), brightness and brightness uniformity, blank-level (BL) and BL uniformity, BL color hue, BL stability, convergence and convergence stability were done with the Advanced Visual Technology System (AVTS) scanning standard (1023 TV lines at 30 frames per second) using video signals from the test pattern generator. In addition, a 5-10 minutes latent image test was done with and without the orbiter circuit energized.

Summary of Test Results. The results of all of the tests have been reported in the attached SODERN minutes of the meeting (Appendix A). The acceptance test results also included in Appendix A are presented in matrix form displaying the actual performance against the specified minimum and goal performance parameters. As can be seen, the SVS-14 met all important minimum specifications and exceeded the specifications in a few areas.

Remarks. When analyzing the test results, the following observations should be taken into consideration:

1. The slightly out of specification luminance uniformity that cannot be discerned by an observer was attributed to the characteristics of the xenon arc and the 90 degree projection optics.

2. The black level, while meeting specification requirements, was found to be not "grey" but rather had a blue hue with reddish areas.

3. The color convergence was marginally acceptable.

4. The SODERN method of calculation for the resolution curve resulted in a MTF of greater than 100% at about 100 P/L.

5. The SODERN light valve technology results in the absence of visible raster lines and a flicker-free image. The DKDP solid crystal inherently has field memory (i.e. a field is continuously displayed until replaced line-by-line by the next field).

Final Acceptance Testing at AFHRL, Williams AFB

Tests Performed. Following in-plant acceptance testing at SODERN in France, the SVS-14 display system was shipped to AFHRL at Williams AFB, Arizona arriving on 19 July 1984. Final testing and evaluation were completed during 1-3 August 1984. Results are recorded in SODERN's minutes of the meeting in Appendix B, which includes a summary of tests, measurements, and analysis in matrix form.

Summary of Test Results. In general, the SVS-14 display system produced vivid color renditions and saturated color, had an excellent contrast ratio (better than 100:1), produced visually flat white and black fields, and had no objectionable blemishes. The image had no visible raster line structure and was virtually flicker-free.

The SODERN projector presented a bright picture through a Pancake Window display, roughly a highlight brightness of 10 foot-Lamberts. This brightness level was measured using a special Lexan (polycarbonate) screen--gain of five. Acrylic screens were shown to be unsatisfactory and exhibiting severe color birefringence with the polarized light output of the SVS-14 and polarized Pancake Window display.

Remarks. Following successful testing of SODERN in France and at AFHRL, the SVS-14 was accepted without waiver. The projector system was transferred on 2 August 1984 to the Air Force.

SODERN/GE Light Valves Comparison Demonstration and Evaluation at AFHRL, Williams AFB

To complement the engineering data collection with human factors information, a SODERN SVS-14/GE PJ5155 Light Valve comparison demonstration was performed 18 October 1984 at AFHRL, Williams AFB.

Tests Performed. The comparison demonstration covered the objective evaluation of video test pattern and AVTS imagery during a simultaneous rear projection onto a side-by-side arrangement of two flat screens. The AVTS imagery included static images and joy stick flights in airfield operation, air-to-air, and air-to-ground scenarios. As part of the demonstration, participants were also asked to rate visual appearance of the two systems using a questionnaire and a rating form constructed for the test.

Summary of Test Results. The analysis of completed forms returned by five raters showed the GE PJ5515 projector to be judged superior to the SODERN SVS-14. Details are recorded in the University of Dayton Research Institute (UDRI) Memorandum in Appendix C.

Remarks. SODERN, immediately after learning about the unfavorable results of the comparison test, voiced reservations on the conduct of the demonstration in a letter to AFHRL/OTE, dated 9 November 1984 (Appendix D). SODERN denied the full validity of the test results due to a partial malfunction of the SVS-14 following a power supply failure that had occurred shortly before the demonstration was performed.

Comparison Test Between SODERN and General Electric Light Valve Projectors at AFHRL/OTE. On the occasion of a maintenance and operations training course held by SODERN at AFHRL/OTE between 3-7 December 1984, the SVS-14 system was overhauled and all major defects eliminated. In order to verify satisfactory performance of the equipment after repair, another side-by-side demonstration of the SVS-14 versus the PE PJ5515 projector was performed on 4-6 December 1984. The test results and the analysis thereof have been recorded in the SODERN report attached in Appendix E.

Tests Performed. For the comparison testing, the same side-by-side arrangement of rear-projection screens as used for the preceding evaluation of the SVS-14 was set up. The measurements included the collection of luminance data on a white square target against a black background, and vice versa. In addition, vertical and horizontal dimensions of the video cross-hatch-grid test pattern were recorded, and an objective evaluation of AVTS static imagery was performed. Finally fast motion simulation was conducted, using a white square that was moved at different velocities across the screen at a variety of tube beam current settings.

Summary of Test Results. Using the brightness data obtained during the measurements, at reverse conditions, illumination uniformity, luminous output and contrast values were calculated. A correction factor was applied to the luminance values, measured near the periphery of the screen to account for the incompatibility of the projection lens used in the SVS-14 with the flat screen. The following conclusions have been derived from the analysis.

1. Luminance output is higher for the SVS-14 with varying contrast and illumination uniformity depending on the background conditions.

2. Light valve tubes delivering higher than specified beam current output show improved persistence of fast moving targets at a marginal degradation of resolution.

3. Perceived image quality of AVTS imagery is better for the GE projector.

Remarks. In spite of SODERN's repair efforts, the performance of the SVS-14 was still affected by a persisting problem with dynamic focusing. The optimum adaptation of the system to computer generated imagery inputs was not achieved due to the lack of time and experience in operating the SVS-14 in conjunction with AVTS imagery.

V. CONCLUSIONS AND FUTURE ISSUES

Conclusions

Acceptance Testing. This paper presented the results and the analysis of engineering and human factors evaluations conducted with the SODERN Visualization System SVS-14. The SVS-14 color light valve projector had been developed by SODERN of France for the General Electric Company for potential use with the Advanced Visual Technology System. At the end of the development phase, the equipment underwent a series of acceptance tests, including:

1. Primary acceptance testing at SODERN in France between 12-16 June 1984 and repeat tests between 26-28 June 1984.

2. Final acceptance testing at AFHRL, Williams AFB between 1-3 August 1984.

The results of the acceptance tests were all satisfactory. The SVS-14 met all important minimum specifications and exceeded the specifications in some areas. The final acceptance tests were also completed successfully and the projector was accepted without waiver on 2 August 1984. The following is a summary of the critical performance parameter results:

Luminance:	2376 lumens (1650 lux, measured on flat screen, with ca 24" radius)
Contrast Ratio:	159:1 (FW to FB field measured at 2V video input amplitude)
Resolution (MTF):	100 P/L at 10% MTF (measured on flat screen, SODERN method of calculation)

Background Raster FOV:	90 degrees circular
Geometric Distortion:	0.25% max in circle 80% of image height
Color Registration:	0.15% max over circle 80% of field (test on flat screen)
Image Stability:	0.15% over 8 hours
Field Rate:	60 fields/sec, 2:1 interlaced
Electrical Interface:	208 V, 60 Hz, 3 phases
Physical Dimensions:	28" H (71 cm) x 37 1/2" W (95 cm) x 21 1/2" D (55 cm), Weight: 330 lb (147 kg)
Other Characteristics	No observed raster structure, field memory capability, flicker-free image, good picture and dynamics with AVTS/IG video, excellent color rendition and contrast

Human Factor Studies. Following the successful acceptance of the equipment and its transfer to the Air Force, further experiments were conducted with the prototype SVS-14 at AFHRL, Williams AFB. These tests covered both engineering and human factors evaluations in order to investigate the projector's performance potential in comparison with existing equipment. These tests include:

1. SODERN/GE light valve comparison demonstration and evaluation at AFHRL, Williams AFB on 8 October 1984.

2. Comparison testing between SODERN and GE light valve projectors at AFHRL, Williams AFB on 4-6 December 1984.

The rating of the visual image quality of the two systems by several participants at the first comparison demonstration favored the GE projector, in spite of the outstanding performance of the SVS-14 during acceptance testing. The reason for this apparent inconsistency was identified by SODERN as malfunction of the SVS-14 due to a partial power supply failure that had not been detected at the time of the demonstration. This was later confirmed during scheduled maintenance.

The secord comparison experiment was conducted while SODERN personnel were on site. This time the engineering measurements and the objective visual evaluation showed an improved performance standard of the SVS-14 but still inferior to that of the GE projector in some areas. The image quality, when projecting AVTS video scenes, still suffered from a persisting problem with dynamic focusing. However, it was established that, for moving targets, image persistence could be improved when using a light valve tube delivering a beam current between 80-120 microamps.

Future Evaluations

Psychophysical Experiments. Both the SODERN projectors and the GE light valve will be further examined at AFHRL in order to obtain physchophysical data on the two systems to complement engineering measurements. The objective of the comparison testing is to find acuity thresholds for stationary and moving targets and for different levels of luminance on both projectors. The experiments have commenced in January 1985 covering stationary targets in five screen positions. They are scheduled to continue in February 1985, with moving targets projected in three orientations (horizontal, vertical, and oblique) and at three different velocities: Data collecting is scheduled to be completed by end of March 1985. These results will be reported in a subsequent technical report.

Other Activities. In July 1985 the SODERN SVS-14 light valve projector is scheduled to be transferred to the Air Force Armament Laboratory at Eglin AFB until December 1985.

APPENDIX A: SODERN MINUTES OF THE MEETING HELD AT SODERN ON 26-28 JUNE 1984, DC/JRH/SD - 4052, DATED 3 JULY 1984

PARTICIPANTS :	Brian GOLDIEZ (US Army)	Bernard MONOD (SODERN)	
	Robert STONE (GE)	F.X. DOITTAU (SODERN) (partly)	
	Jean DENIS (SODERN)		
	Jean R HURIET (SODERN)		
	Patrick MALAUZAT (SODERN)		
LIEU :	Limeil-Brévannes (FRANCE)	**DATE** :	June 26-28, 1984

	ACTION
1 - First day of the visit used for travel to Brive, center of FRANCE, at HYPERELEC/RTC plant where the TITUS light valve is produced. Manufacturing and test facilities are presented as well as computerized measurement room. Most of the process is automatically controlled. Production capability is for 200 tubes per year, or more. Then an improvement program to reach 1500 (or possibly 2000) pixels per line is presented and argumented, from today status demonstrated with the new light valve (see attached curves in annex 1). The technical works for adequate results are given and described.	
2 - Inspection of measurement tests results obtained with the SVS 14 visualization system leads to the final comments as per attached data sheets in annex 2 p 1 to 6. The basic data from which these values are taken is the SODERN acceptance test report 4011 142 2370 1 B p 365 dated June 18-22, 1984, a full copy of which is given to all participants for review. These tests results are accepted.	
3 - Performance of additional tests with a flat screen : In agreement with GE and US ARMY, the SVS 14 is modified in order to set special optics made available by SODERN for projection onto a flat screen instead of a spherical screen. The measurement results are given in annex 3, 4 and 5. Key results are : - Determination of suitable beam current which is found as being between 40 to 50 µA for fast motion images (see 3.1). - Latent image measurement and observation after 10 minutes static display with and without orbiter. The remanent image is negligible with orbiter (see 3.2) and very very low without orbiter (see 3.3).	

ACTION

- Modulation is measured (4.1) (4.2) and the result is 13 % at 800 p/l and 20 % at 665 p/l according to acceptance test method (contrast) and 8 % at 800 p/l - 14 % at 665 p/l according to optical measurement method (modulation). Specification is 10 % at 700 p/l (contrast) which means 7 % modulation.

- Black level uniformity (4.3) (4.4) and stability over 16 hours. The contrast is also measured as well as the white level uniformity (4.5). The luminous output at white level is 2500 lumens (which gives 485 lux at screen center). The black level is within the specification. But GE make comments that the color uniformity of black is not sufficient. The level of black being 1/100 of white level seems too high for night scenes, the use of a polarizer will allow to adjust it to suitable level, demonstration is made corresponding to ~ 3-5 % of transmission corresponding to pancake window. Black looks black with this level.

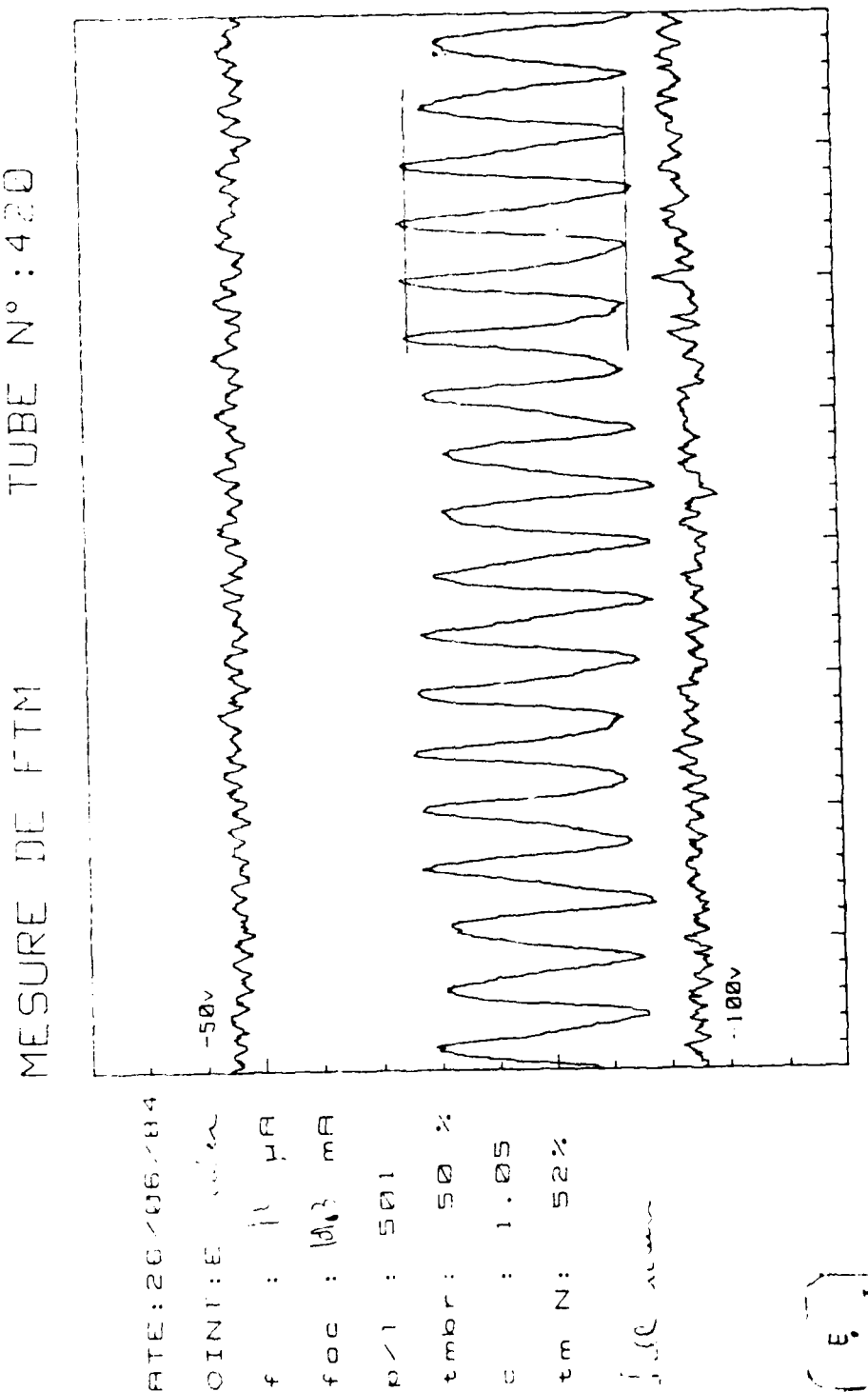
4 - The test results report is accompanied by the reports documenting what is not measured (LER 25508 dated June 84).

5 - Additional measurement June 28, (05 pm) 1984
Uniformity of black is the same as previously. Uniformity of the white is better at top and on the left, less good on the right but all values are still within the specification. See annex 5.1, 5.2, 5.3. Contrast versus frequency is also the same, ~ 13 % at 800 p/l and 25 % at 665 p/l. These tests will be repeated in Phoenix/HRL.

6 - Installation at Phoenix
July 16th, SVS 14 available at New-York customs for GE to proceed with the paperwork, GE to send immediately a telex to SODERN after clearance of customs. This telex will authorize SODERN personnel to fly to Phoenix. S
SODERN personnel will arrive in principle July 17th-6 pm. GE
GE transports the crates from Phoenix airport to HRL.
SODERN personnel will be there for opening of the crates, and proceed to the installation after unpacking with local assistance from GE. S
Test at HRL between 30th of July and 3rd of August.
This supposes USAF gives the clearances to SODERN personnel to work in their facilities.
SODERN brings the test pattern generator, GE takes care of the measurement equipment.

	ACTION
7 - Documentation presented to GE/US ARMY is agreed exept comments about english vocabulary in some pages and some missing references. This concerns maintenance documentation vol 1 to 4 (about 1500 pages and drawings) plus user's manual and technical description. All these documentations will be packed and shipped with the SVS 14.	S
8 - Spare parts : Open point to be checked with USAF.	GE
The original hand-written version of these minutes of the meeting is duly signed by General Electric and SODERN representatives.	

Annex 1


MESURE DE FTM
TUBE N° : 420
-50v
-100v
DATE : 26/06/84
POINT : E
If : 11 µA
Ifoc : 10,2 mA
Np/l : 501
Ftembr : 50 %
Fc : 1.05
Ftm N : 52%

MESURE DE FTM TUBE N° : 420

DATE : 26/06/84

POINT : E Centre

If : 60 uA

Ifoc : 104 mA

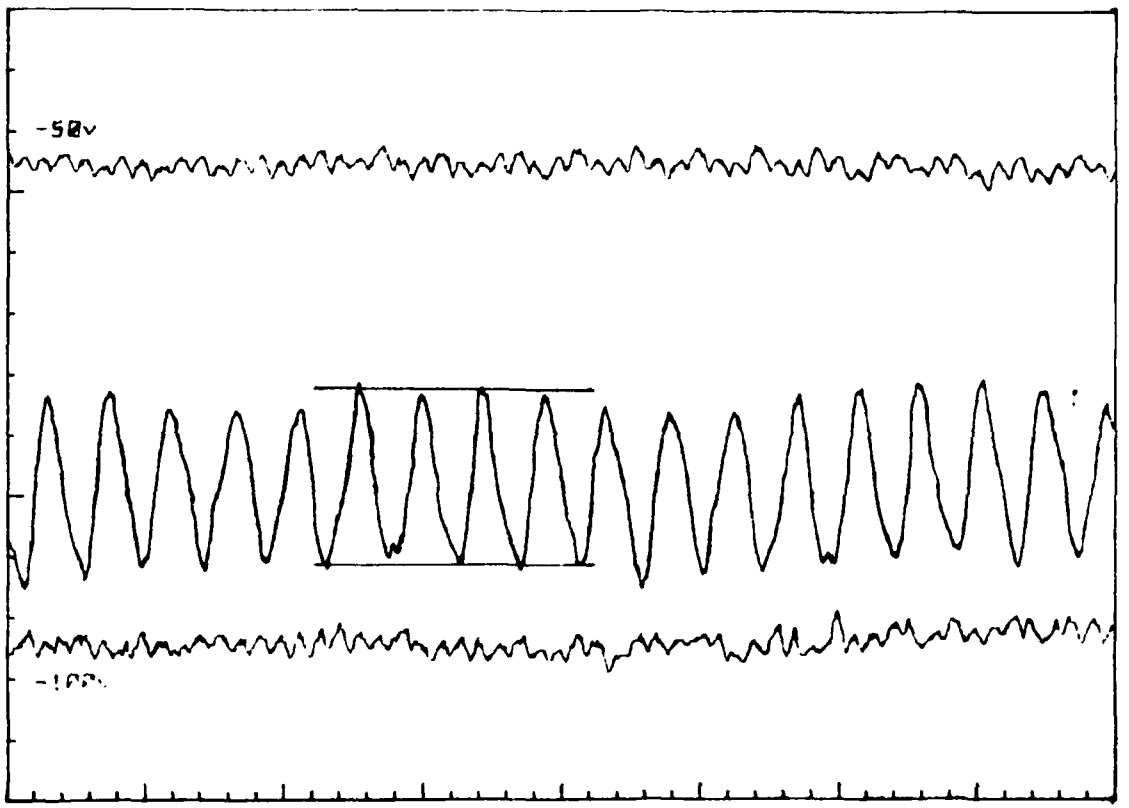
Np/l : 501

Ftmbr : 37 %

Fc : 1.05

Ftm N : 38%

Une fenêtre = full screen



Annexe 1

MESURE DE FTM TUBE N° : 420

DATE : 26 / 06 / 84

POINT : (bas droite)

If : 60 µA

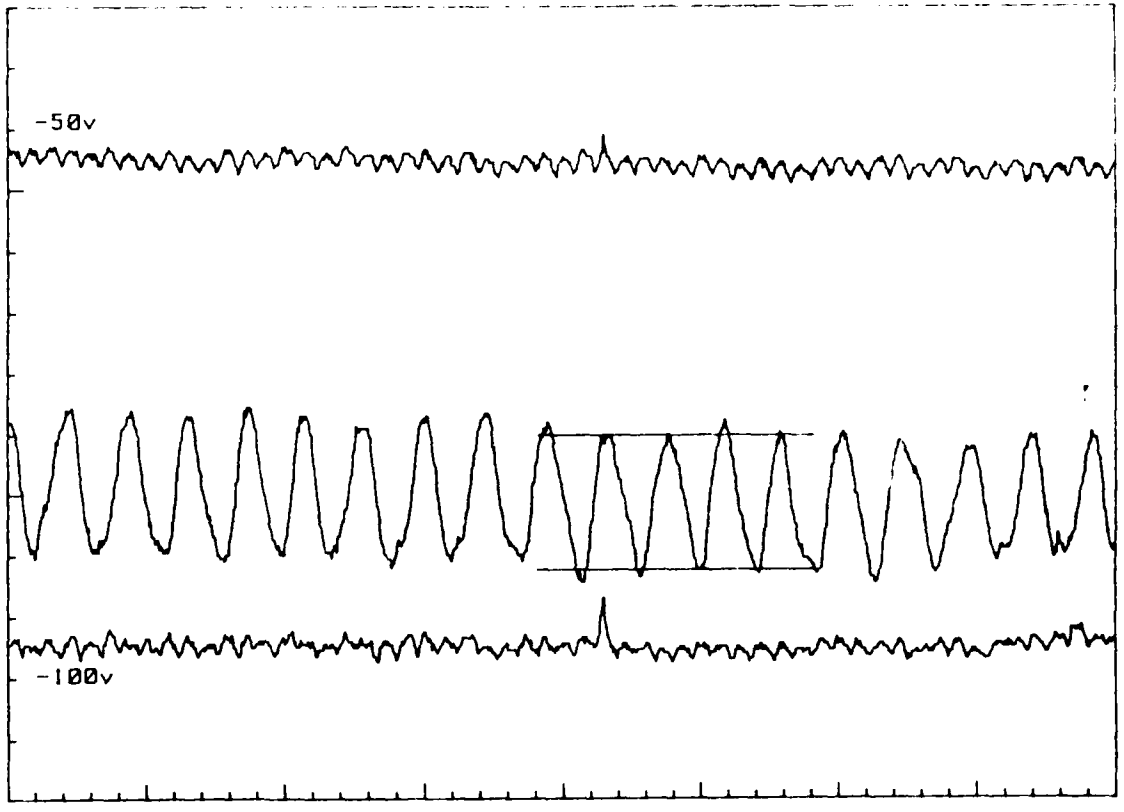
Ifoc : 10,3 mA

Np / 1 : 516

Ftmbr : 28 %

Fc : 1.05

Ftm N : 30%



Annexe 1

MESURE DE FTM TUBE N° : 420

DATE : 26/06/84

POINT : ↓ (en bas droite)

If : 10 µA

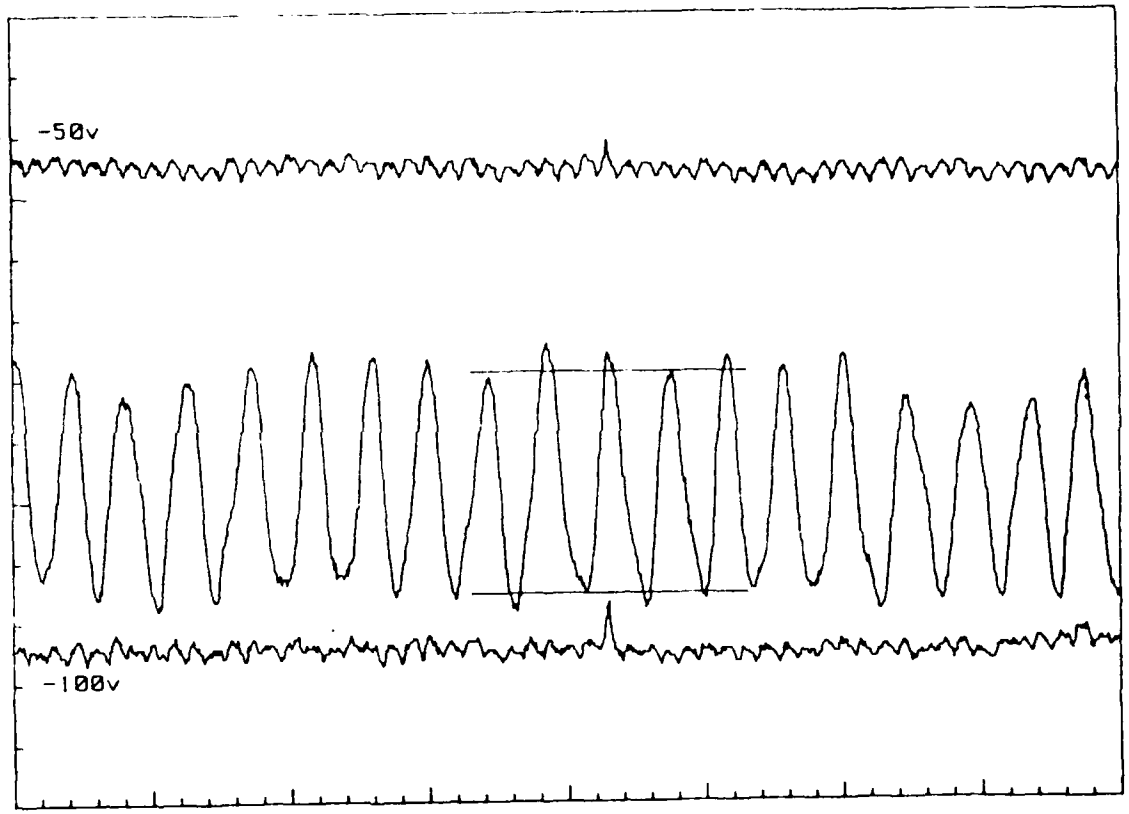
Ifoc : 100,2 mA

Np/1 : 523

Ftmbr : 46 %

Fc : 1.05

Ftm N : 48%



Annex 1

MESURE DE FTM TUBE N° : 420

DATE : 26/06/84

POINT : E

If : 60 uA

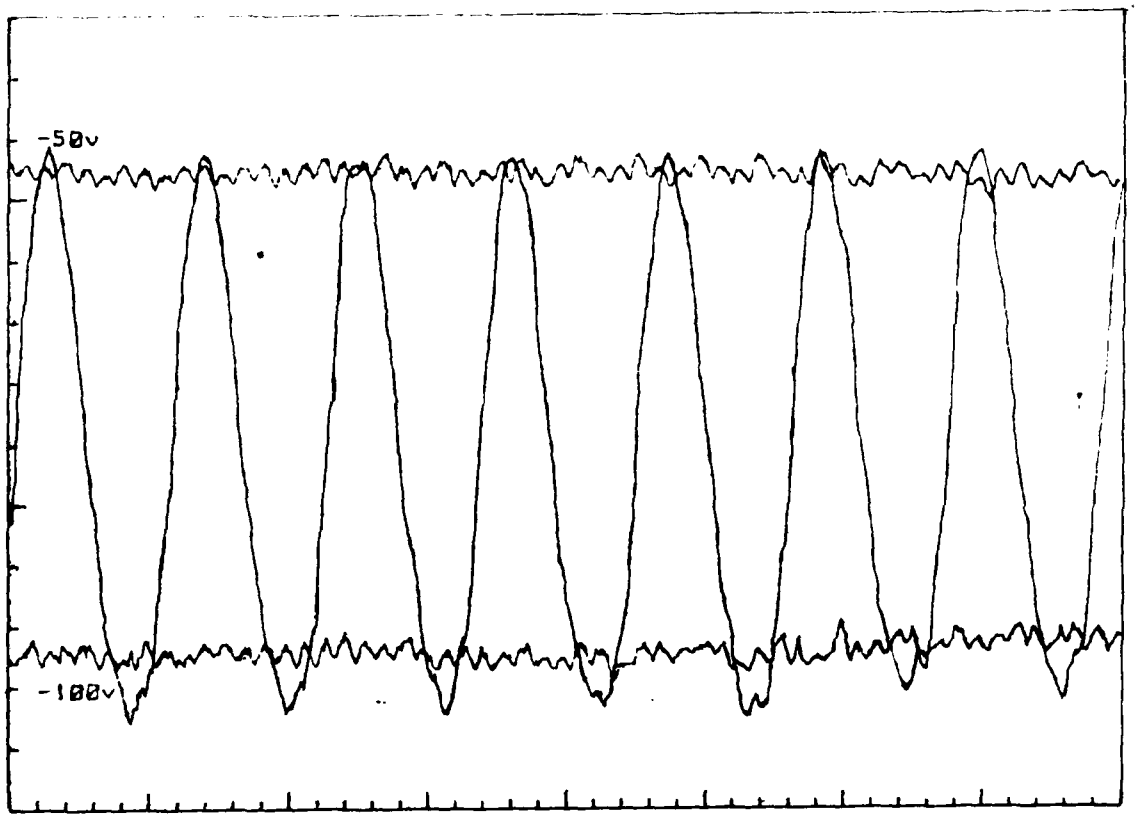
Ifoc : 104,5 mA

Np/I : 187

Ftmbr : 110 %

Fo : 1,02

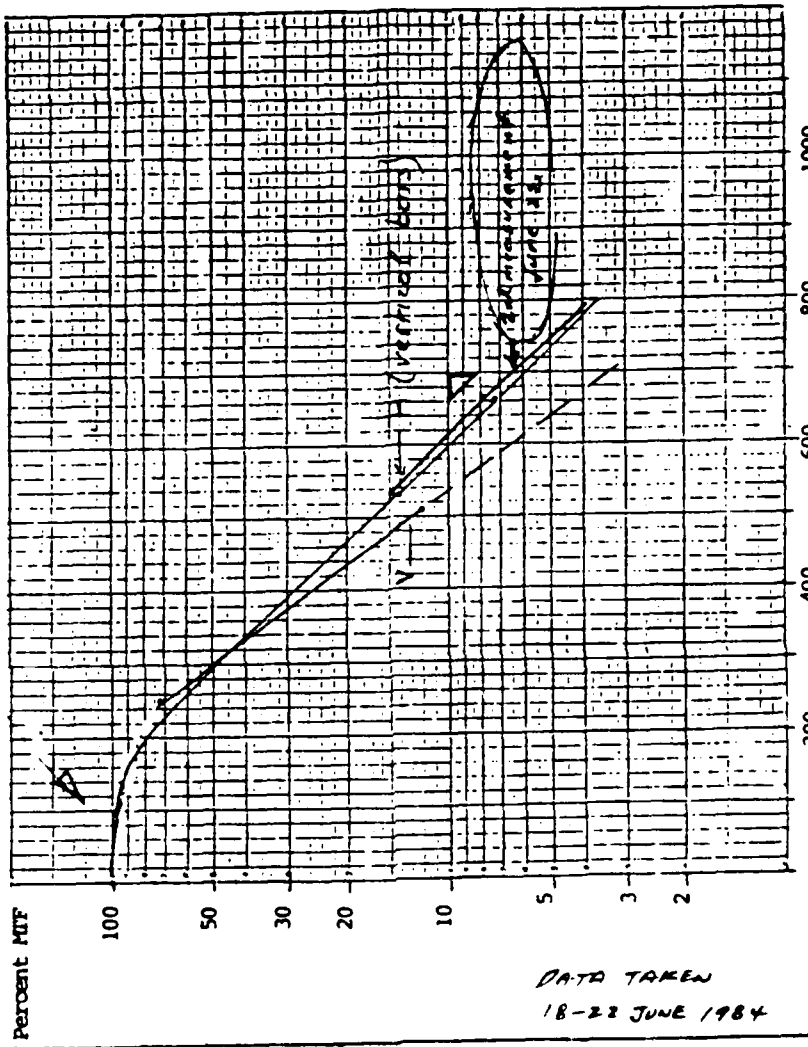
Ftm N : 112%



Annex 1

H AND V MTF - POINT O (center) ANNEX

$\frac{max - min}{max + min} \Big/ \frac{max_O - min_O}{max_O + min_O}$ ← "INDUSTRY" METHOD OF CALCULATION

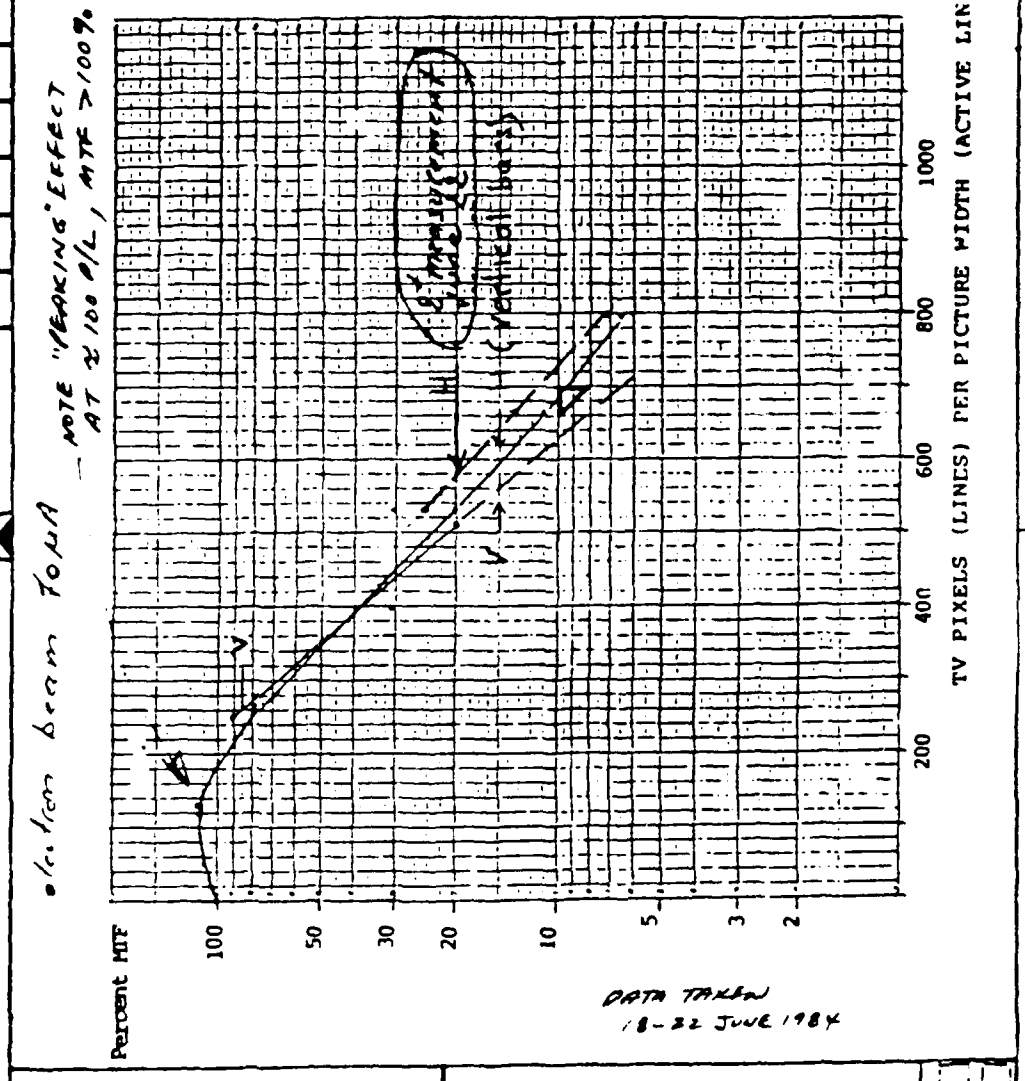


DATA TAKEN
18-22 JUNE 1984

ENS SUP PAGINE	SODERN ACCEPTANCE TEST REPORT FOR SVS 14 (OPTION 1)
ETABLI PMz/sm LE 2.4.84	A4 4011 142 23701
VERIFIE LE	
APPROUVE LE	PAGE 365 FOLIO 1
REMPLACE	SODERN 1 Av Descartes 94450 LIMEIL BREVANNES

H AND V MTF - POINT O (center) ANNEX

$\frac{max - min}{max_0 - min_0}$ ← "SODERN" METHOD OF CALCULATION



ENS SUP PAGINE

SODERN ACCEPTANCE TEST REPORT FOR SVS 14 (OPTION 1)

ETABLI	PMz/sm	LE 2.4.84
VERIFIE		LE
APPROUVE		LE
REMPLACE		

A4 4011 142 2370 K

PAGE 365 FOLIO 1

SODERN 1 Av Descartes 94450 LIMEIL BREVANNES

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
•LUMINANCE (ILLUMINANCE)	3 1 1	1950 LUMENS (125 FOOT CANDLES MEAS AT CENTER OF SCREEN)	2500L (160 FC)	128FC		Accept	Measure with a Photometer at the virtual screen location
•LUMINANCE UNIFORMITY	3 1 2	MAX VARIATION ±15% FROM NOMINAL (MEDIAN) IN FOV	(SAME)	1.3 to 1.66 (5 % measurement accuracy)		Accept (slightly out-of-specifications. Due to Xenon arc and projection lens)	Measure as above Corner 1 2 ±15% of center = 1.02-1.38 acceptable. due to F tangent theta lens characteristic
•CONTRAST RATIO	3 1 5	80 1 WITH FW TO FB FIELD (HW/HB 45 1 HW/BF 29 1)	100 1 (FW/FB)	115:1 FW/FB 51:1 HW/HB 48:1 HW/BF		Accept	Measured with an input video signal (black-to-white) of 2V p-p
•GAMMA CORRECTION	3 1 17	9 LEVELS EA 12 5% (±5%) (8 STEPS)	(SAME)	Within 7.5 - 17.5%		Accept	Measure without/ with lens polarizer Also measure with gamma circuit switch "off"
•RESOLUTION (MTF)	3 1 3	700 TV LINES (PIXELS) PER HORIZ LINE AT 10% MTF OFF-AXIS POINTS, ≥20 DEG , ≥8% MTF	850 P/L AT 10% MTF (OFF-AXIS ≥8% MTF)	On axis : H700P/L-12&MTF V700P/L-6.5%MTF H700P/L-6%MTF V700P/L-3.3%MTF Off axis : H700P/L-10%MTF V700P/L-4.5%MTF	SODERN METHOD 6/22/84 INDUSTRY METHOD 6/22/84 SODERN METHOD 6/22/84	Green LV to be replaced (see below). MTF meas to be repeated prior to shipment.	Use SODERN method of calculating from data Also, calculate % MTF = (max-min)/(max+ min) x 100 H and V MTF shall be identical (Test at AFHRL may be subjective)
FLAT FIELD	3 1 9	NO VISIBLE RASTER OR BLEMISHES (PER SPEC SHEETS 35-36)	(SAME)	Evaluated 6/28/84		Scratches and blemishes on green LV requires a replacement LV	Includes no visible "roof" effect at all video levels

•INDICATES TEST TO BE REPEATED AT AFHRL. PERHAPS IN A MODIFIED FORM

Repeat resol. meas on a flat screen after SVS-14 is optimized (tuned).

On axis : H[illegible]P/L V700P/L 87% SODERN METHOD 6/28/84 798 p/L 13%

Off axis : H700P/L V700P/L SODERN METHOD 6/28/84

RFS 25 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST / REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
*BACKGROUND RASTER FOV	3 1 7 1	90 DEG CIRCULAR FOV	(SAME)	Checked O.K.	Accept	Adjust H+V Size for Square Format to encompass pentagonal window
*MAPPING CORRECTION	3 1 4 1	N/A	(25% ADJ RANGE)	Can adjust to spherical screen	N/A Measurement range recorded in SODERN documentation.	Measure Adjustment Range (Will need to adjust at AFHRL with ILIOS window)
*GEOMETRIC DISTORTION	3 1 4 2	≤0.5% IN CIRCLE 80% OF IMAGE HEIGHT	≤0.25% (ETC , SAME)	0.25% max.	Accept	Check geometric distortion at the end of image stability test (3 1 10)
*COLOR REGISTRATION (convergence)	3 1 14	≤0.05% OVER A CIRCLE 80% OF FIELD, ≤0 1% OVER TOTAL FIELD	(SAME, BUT OVER ENTIRE FIELD)	0.15% max. over circle (test on flat screen 6/28-29/84)	There appears to be a problem in securing and maintaining proper convergence on a spherical or flat screen. SODERN must resolve.	Check color registration at the end of image stability test (3 1 10)
IMAGE STABILITY	3 1 10	≤0 5% OVER 8 HOURS	≤0 2%	0.25%	Accept	Perform a BL stability test at the same time
FIELD RATE	3 1 15	60 FIELDS/SEC. 2 1 INTERLACED	(SAME)	Checked with scope against VII signal generator.	Accept	Set VII Signal Generator for proper standards

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

Annex L

2.2

21

RFS 25 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
REPOSITIONING (BLANKING)	3 1 8	VERT BLANKING ≤619 usec HORIZ BLANKING ≤7 usec	(SAME)	Checked with scope O.K.		Accept	Set VII Signal Generator for proper standards
*DISPLAY TIME RESPONSE (LATENT IMAGE)	3 1 6	PER SPEC 40% AFTER 1 FRAME, 10% AFTER 2 FRAMES, 0 3% AFTER 3 AND 4 FRAMES. (OVERWRITE AFTER 5 MIN OF STATIC SCENE)	(SAME)	30.5% after 1 frame ≈ 20% after 2 frames 70 μ amp. beam current)		Accepted (Re-checked 6/28/84 . The latent image effect with and without orbiter "on").	Check with/without Orbiter switch on. (Subjective test only at AFHRL) Min. latent image effect with orbiter on.
OPTICAL SYSTEM AND PROJECTION LENS	3 1 18	90 DEG FOV. 24 IN RADIUS SCREEN. EXIT PUPIL WITHIN ±0 25 IN OF COC THROUGHOUT FIELD	(SAME)	Checked O.K. measurement swivelling range	Checked analysis	Accepted	Check Swivelling Range of Projection Lens Do at SODERN Radius of spherical screen measurement 575.7 (not 609.6)
*ELECTRICAL INTERFACE	3 2 1	208V, 60 Hz, 1 PHASE, (TBD)KW 208V, 60 Hz, 3 PHASE, (TBD)KW	(SAME)	All unit power supplies tested on 208 V & 197 V on 50 Hz		Accepted	Test at SODERN on 220/380V, 50 Hz Measure power required Verify performance on 208V, 60Hz at at AFHRL
MECHANICAL INTERFACE	3 2 2	PROJ VOL <0 37 cubic meter PROJ SIZE <95 x 70 x 55 cm PROJ WEIGHT <136 kg WITHOUT 110 kg COOLING SYSTEM (<150 WITH)	(SAME except 110 kg total weight)	O.K. but 162 ± 3 kg with cooling equipment		Accepted	Reference applicable SODERN report SODERN must evaluate pentagon window 4, 7, 8 and 13 positions. More information needed.

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

RFS 25 May 84

CHECKLIST SUMMARY FOR BVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
•OPTICAL INTERFACE	3.2.3					To be done at AFHRL.	Initially with an Off-Platform Window at AFHRL
•DATA (SIGNAL) INTERFACE	3.2.4			Checked with H+V drive 6/28/84		Accepted.	Check Individual H+V Sync Drive and Comp H+V Drive
EMI AND SUSCEPTIBILITY	3.3.2				Analysis included in SODERN documentation.	Accepted.	Define design/ analysis done on EMI
COOLING REQUIREMENTS, ENVIRONMENTAL REQUIREMENTS	3.3.4 3.8	OPERATING TEMP RANGE (+15 TO +25 DEG C) HUMIDITY 0-90% NON-CONDENSING	+15 DEG TO +30 DEG C (OTHERWISE SAME)	SODERN tests with thermal model		Accepted. (Operation at 30°C assumed)	Report results of Thermal Model Tests at SODERN
RELIABILITY	3.4				Analysis included in SODERN documentation.	Accepted.	600-800 Hrs MTBF per SODERN calc SODERN calculations higher (1653 Hrs MTBF)
FAILURE ANALYSIS	3.4.1				Analysis included in SODERN documentation.	Accepted.	Define analysis done, if any (analysis results in ∝ 20 component changes)

•INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

Annex L

2.4

RFS 25 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
MAINTAINABILITY	3 9			N/A	Analysis included in SODERN documentation.	Accepted.	Discussion of Method of Replacing LVs at Site and Spares MTTR calculations is 43 min. (Specification is 60 min.)
SAFETY	3 6			N/A	Discussion included in SODERN documentation.	Accepted.	Discuss safety aspects Eye damage and X-rays from Xenon Arc? (No X-ray problems. Care to be taken in changing Xenon arc)

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

Annex L

2.5

RFS 25 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
BLACK LEVEL STABILITY	3 1 16	N/A	N/A	N/A	N/A	N/A (Problem in getting a uniform flat "grey" black level. Color is green with red tint)	Recommend a Test Measurement--for Information
MIN. BLACK LEVEL (NIGHT SCENE)		N/A	N/A	N/A	N/A	N/A Minimum black level too high on a flat screen or dome). Must use a lens polarizer.	Recommend a Test Measurement--for Information Combine with image stability test
*PROJECTED IMAGE ON A FLAT SCREEN		N/A	N/A	N/A Tests made 6/27-28/84 at SODERN	N/A	N/A	For demo only at AFHRL (Use of another Projection Lens) Loan to AFHRL.
*DYNAMIC IG SCENE PERFORMANCE		N/A	N/A	N/A Test with new AVTS IG.	N/A	N/A	Subjective evaluation of a full color dynamic IG scene at AFHRL. thru a window and on a screen. for demo only
Dynamic video disc tests made on 625 lines, 25 frames see at SODERN.						N/A	Useful subjective data on image smear versus LV beam current (approx. 50 u amp. rather that previously used 70 u amp. appears O.K.)

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

Annex 2

2,6

Annex 3 — 3.1

SVS 14 Test — June 27, 1984

Determination of suitable beam current for fast motion display

- Test is done with 5 witnesses not knowing the used beam current. Witnesses are BG - BS - JD - PM - JRH -
- The source is a video disc with several sequences showing different light level at different speed of motion.
- The beam current used is randomly selected in the range of 10 to 70 μA with two times 40 μA
- Y means acceptable
  N means not acceptable
- Results :

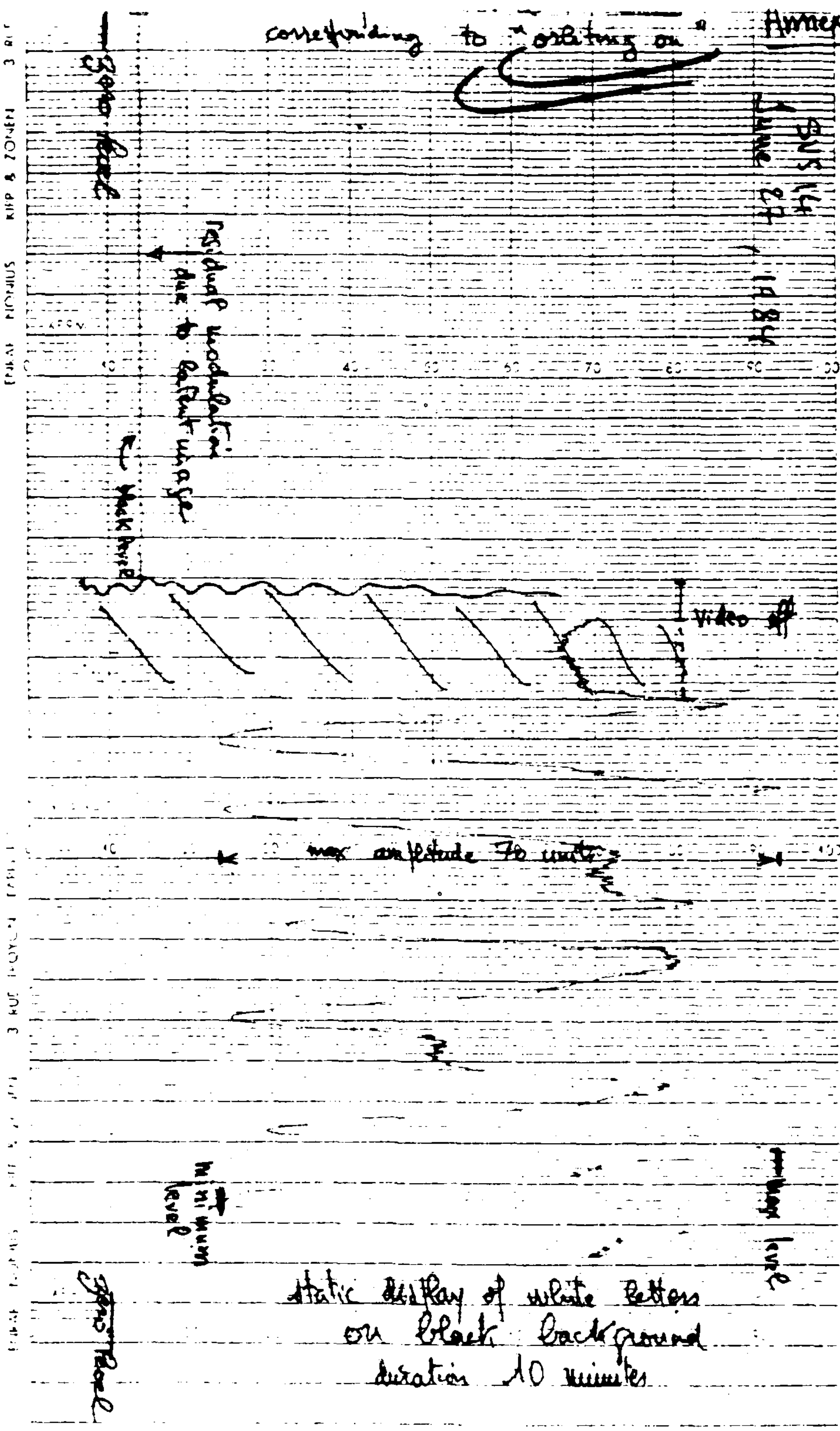
Test NR	μA	BG	BS	JD	PM	JRH	Total	
1	10	N	N	N	N	N	0Y, 5N	●
2	40	Y	Y	Y	Y	Y	5Y, 0N	○
3	60	Y	Y	Y	Y	Y	5Y, 0N	○
4	20	N	N	N	N	N	0Y, 5N	●
5	30	N	N	Y	N	N	1Y, 4N	●
6	70	Y	Y	Y	Y	Y	5Y, 0N	○
7	50	Y	Y	Y	N	N	3Y, 2N	◑
8	40	N	N	Y	N	Y	2Y, 3N	◑

- Conclusion :

A beam current of 40 to 50 μA is acceptable for fast motion

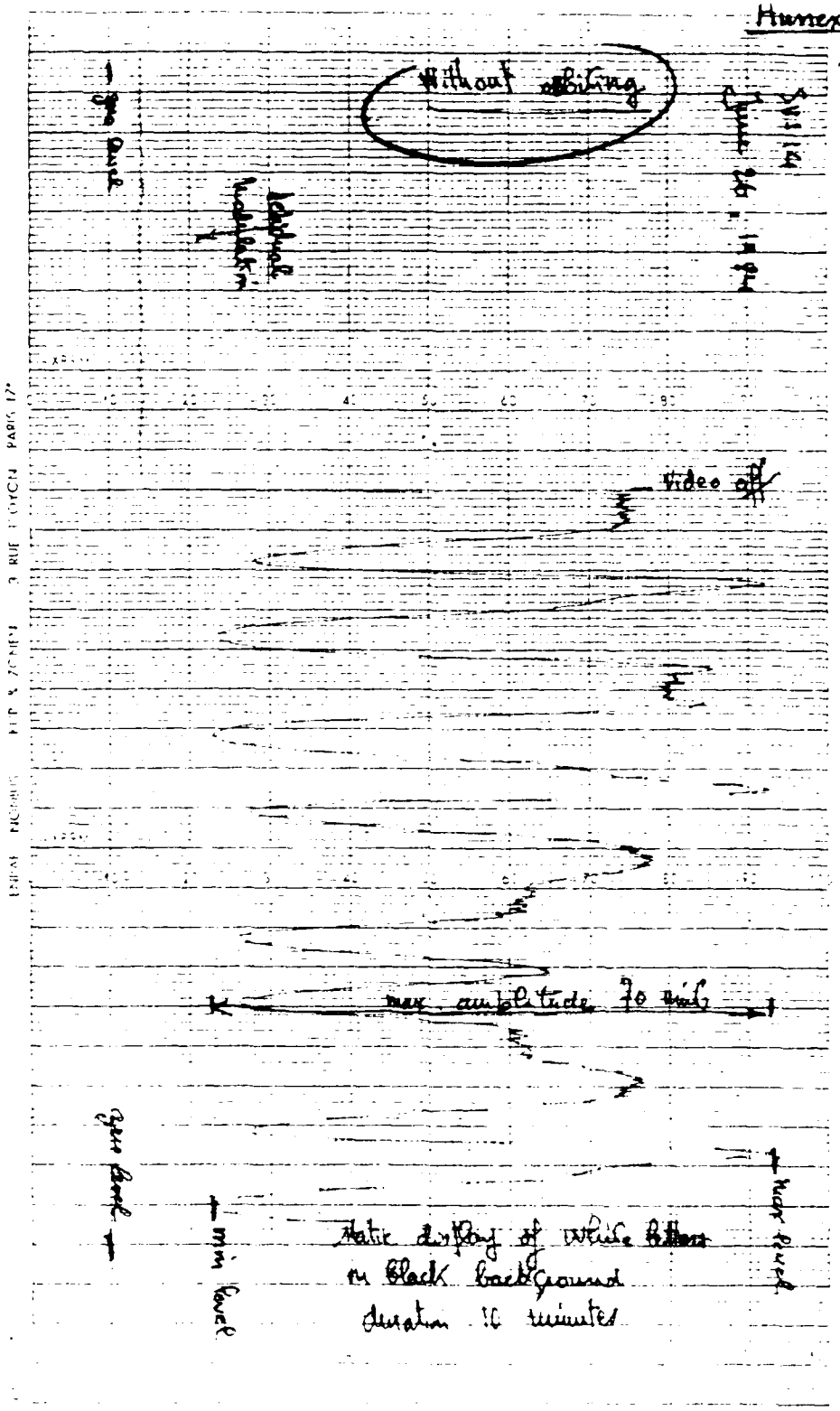
Annex 3

3.2


corresponding to orbiting on
SVS 14
June 27, 1984
Zero level
residual modulation due to latent image
black level
video
max amplitude 70 units
minimum level
max level
Static display of white letters
on black background
duration 10 minutes
Zero level

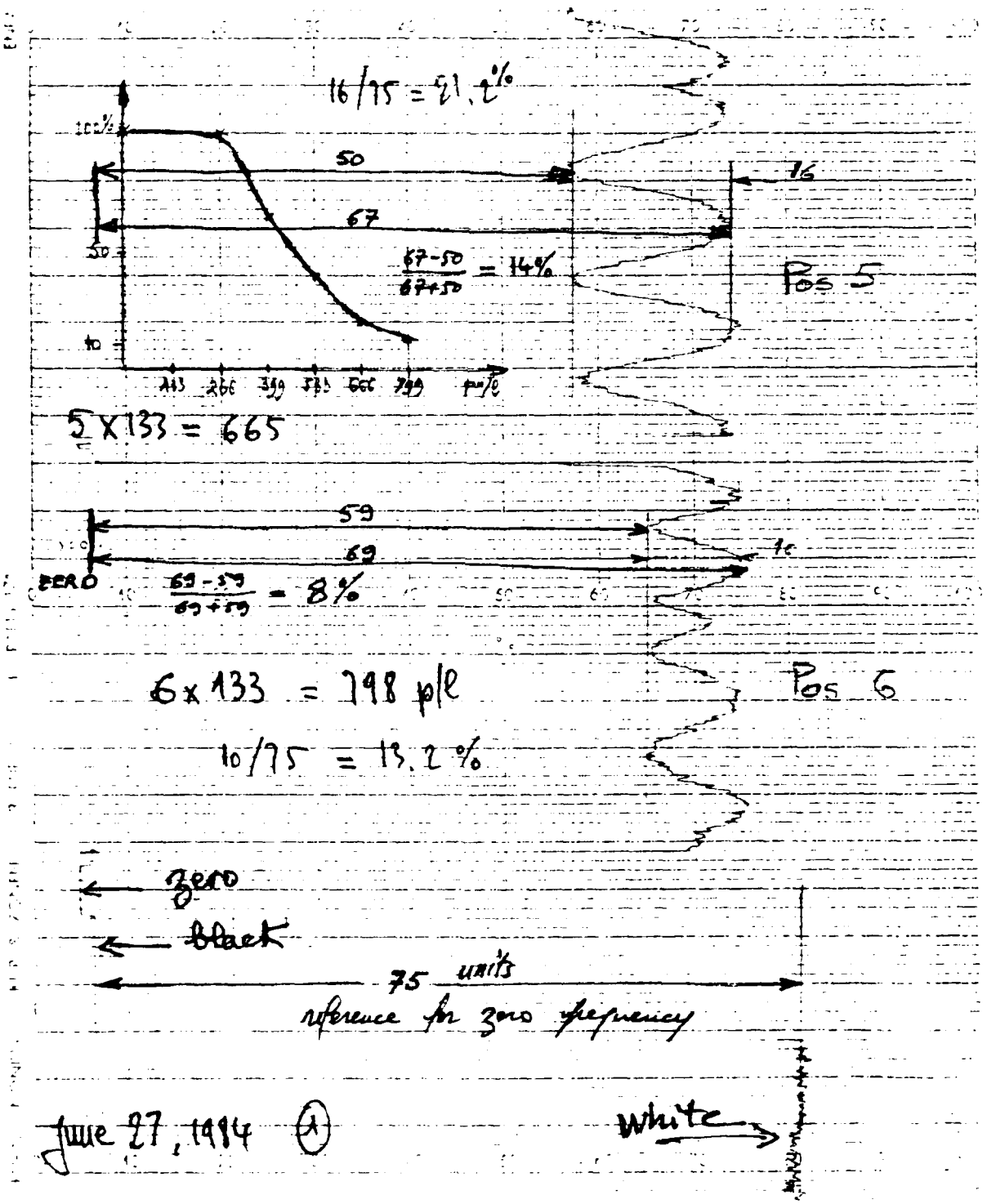
Annex 3

3.3

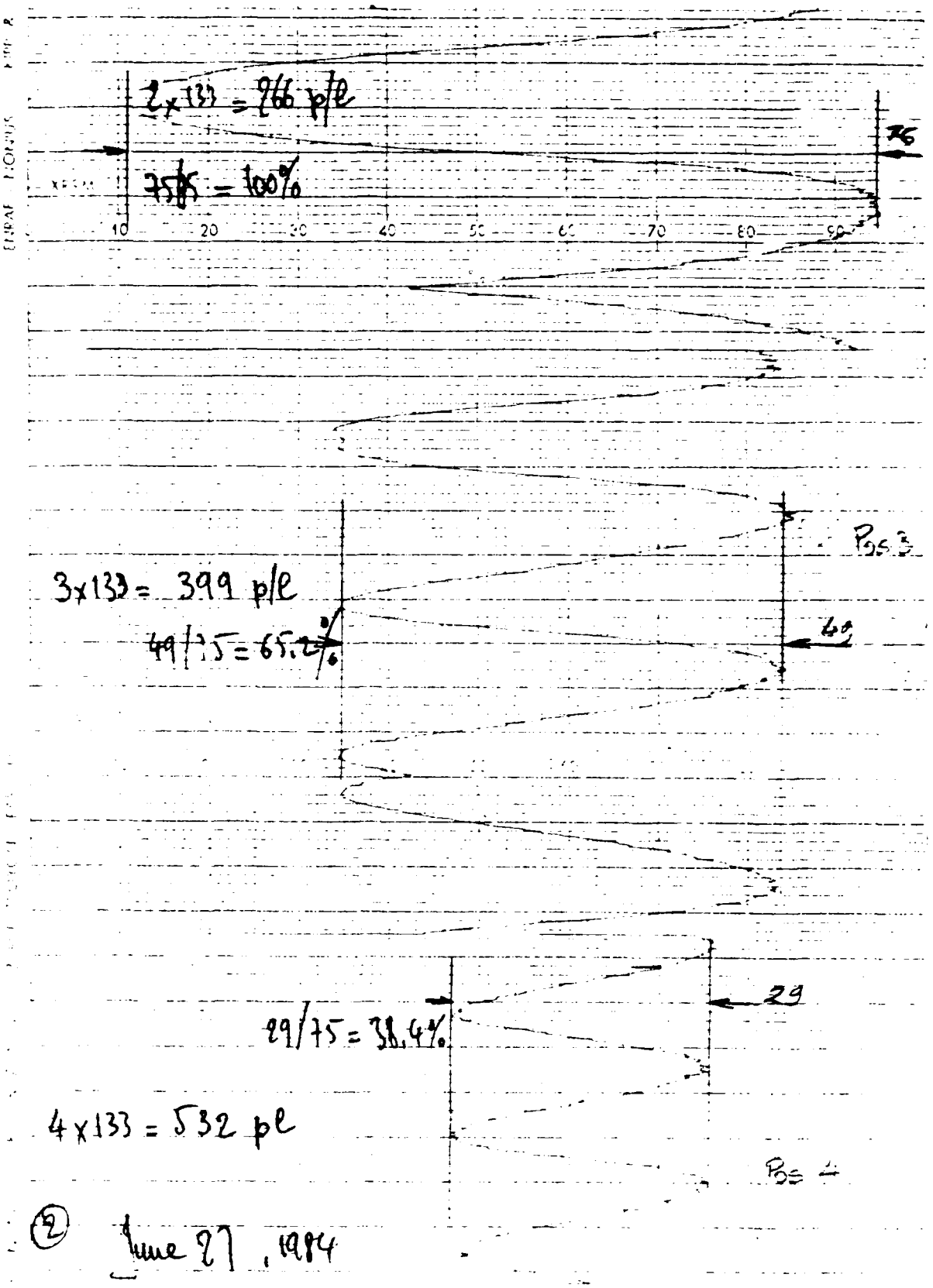

without adapting
video off
max. amplitude 70 mV
Static display of white letters
on black background
duration 10 minutes

Annex 4

4.1


16/75 = 21.2%
100%
50
67
50
to
16
67-50 / 67+50 = 14%
Pos 5
133 266 399 533 666 799 p/p
5 X 133 = 665
59
69
ZERO
69-59 / 69+59 = 8%
6 x 133 = 798 p/l
Pos 6
10/75 = 13.2 %
zero
black
75 units
reference for zero frequency
white
June 27, 1994 (1)

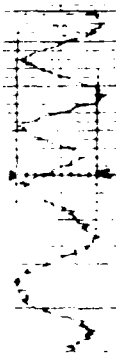
Annex 4 4.2



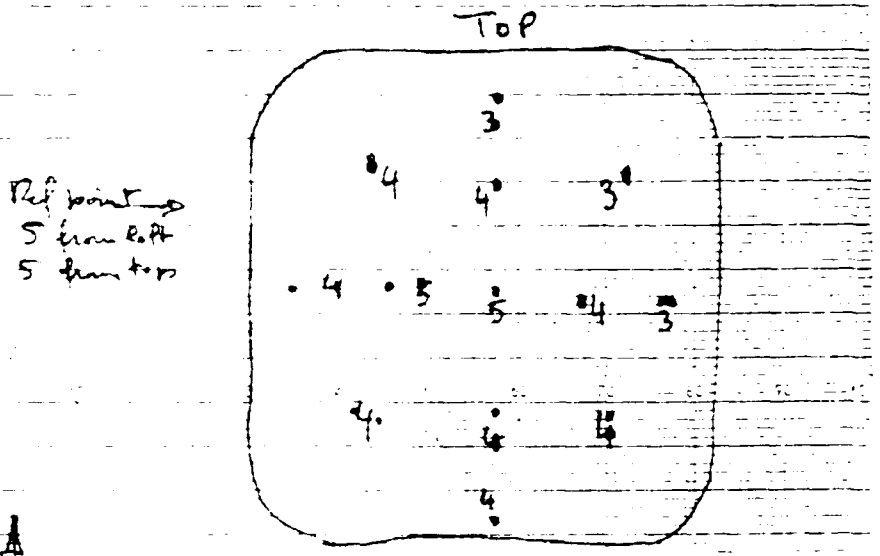
② June 27, 1984

June 27 - 06 00 pm

Verification:
Modulation at Kr 137 : 798 p/L
9/75 = 12 %



Contrast: $\frac{475}{5} = 95$ at center between black and white

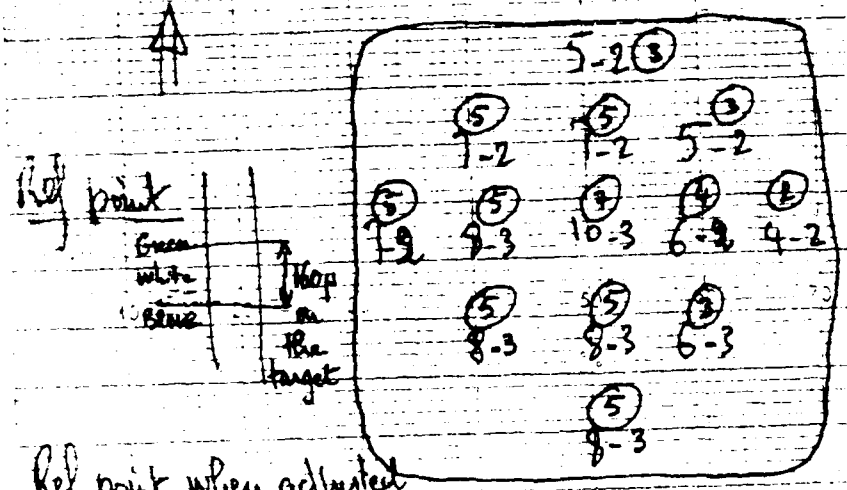


June 27 - 17.00 (3) Black level uniformity

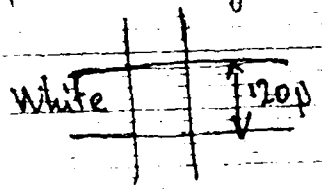
Annex 4

White level with 10% video : 370 lux at centre

Misconvergence effect:
40 µ on target = 0.1% over 16.30 hours continuous operation



Ref point when adjusted

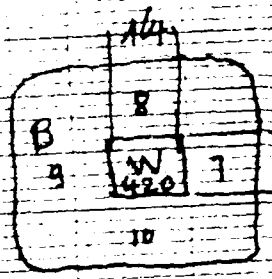


June 28 - 09.30 am (4)

June 27 - 06.00 pm

June 28, 1984 (5)

$C = 460 / \left(\frac{(3+2+10+7)}{4}\right) = 49,4$

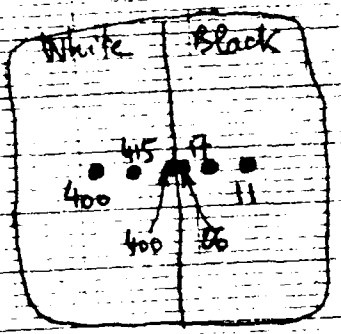


Contrast after 16.5 hours

$C_1 = 400/11 = 36,4$

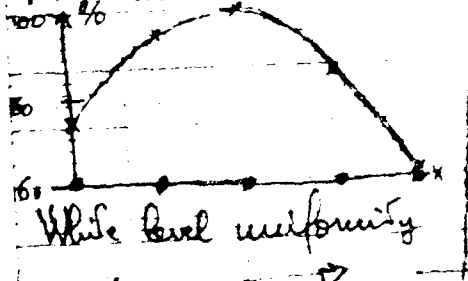
$C_2 = 415/17 = 24.4$

$C_3 = 400/26 = 15,4$

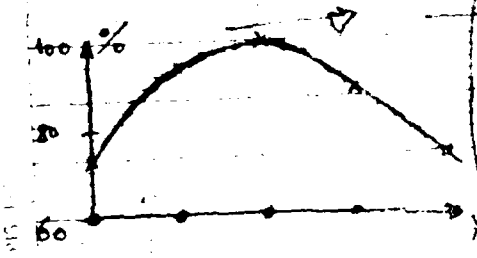


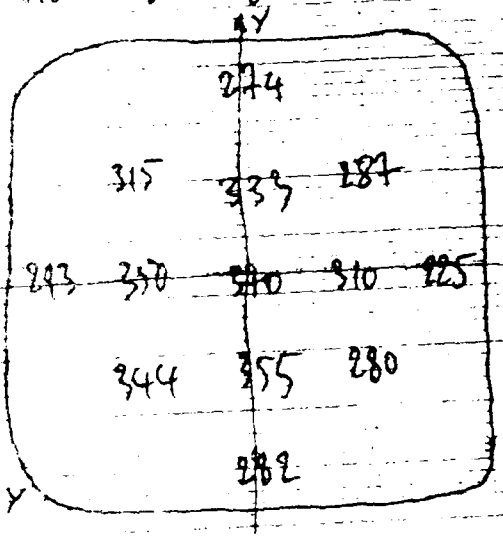
$\frac{\text{Full white}}{\text{Full black}} = \frac{\Sigma W}{\Sigma B} = \frac{4015}{57} = 71.5$ average all over the field

White level with 100% video : 485 at center (ie 2499 lm/m²)



White level uniformity





Screen area 5.15 m²

Annex 5

5.1

June 28, 1984

Uniformity

black

3

4 4 3

5 5 5 3 3

5 4 4

4

Uniformity

white

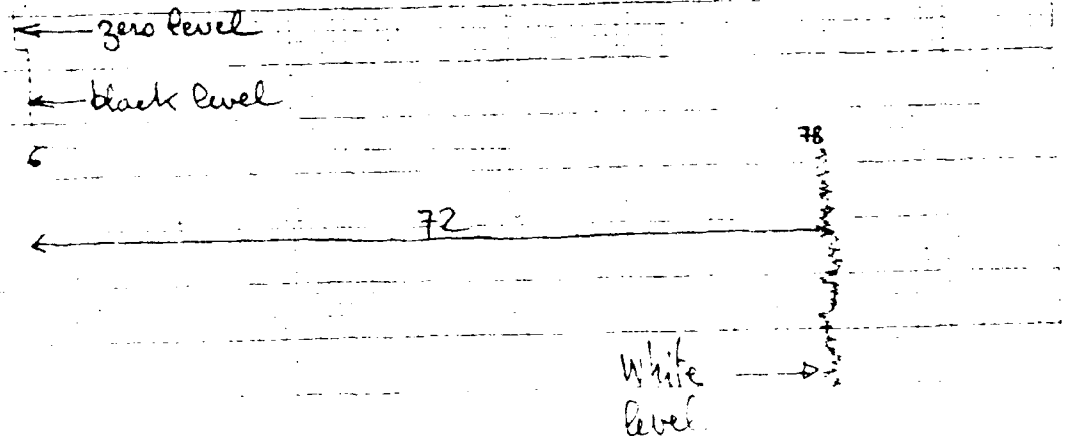
246

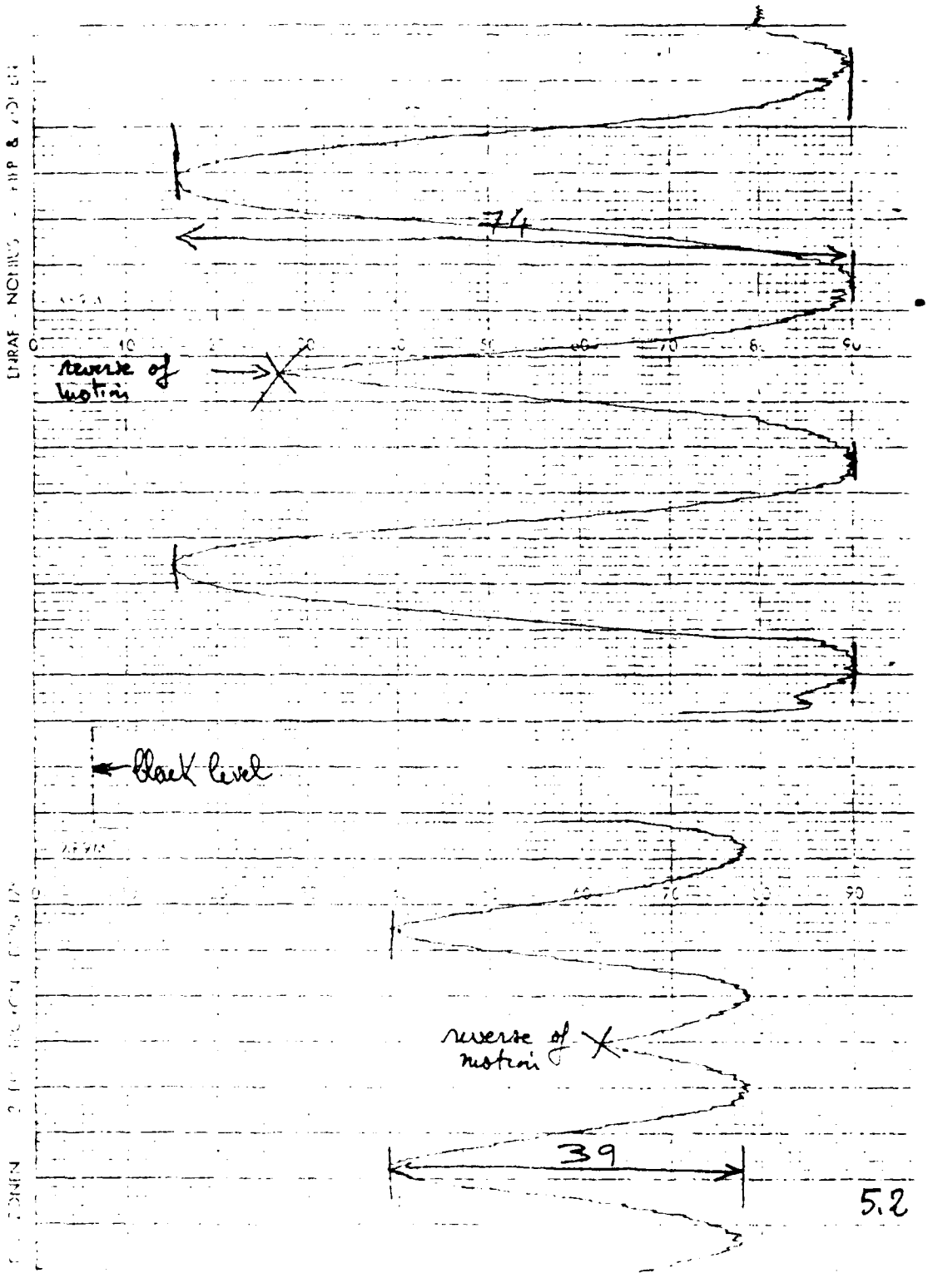
294 315 259

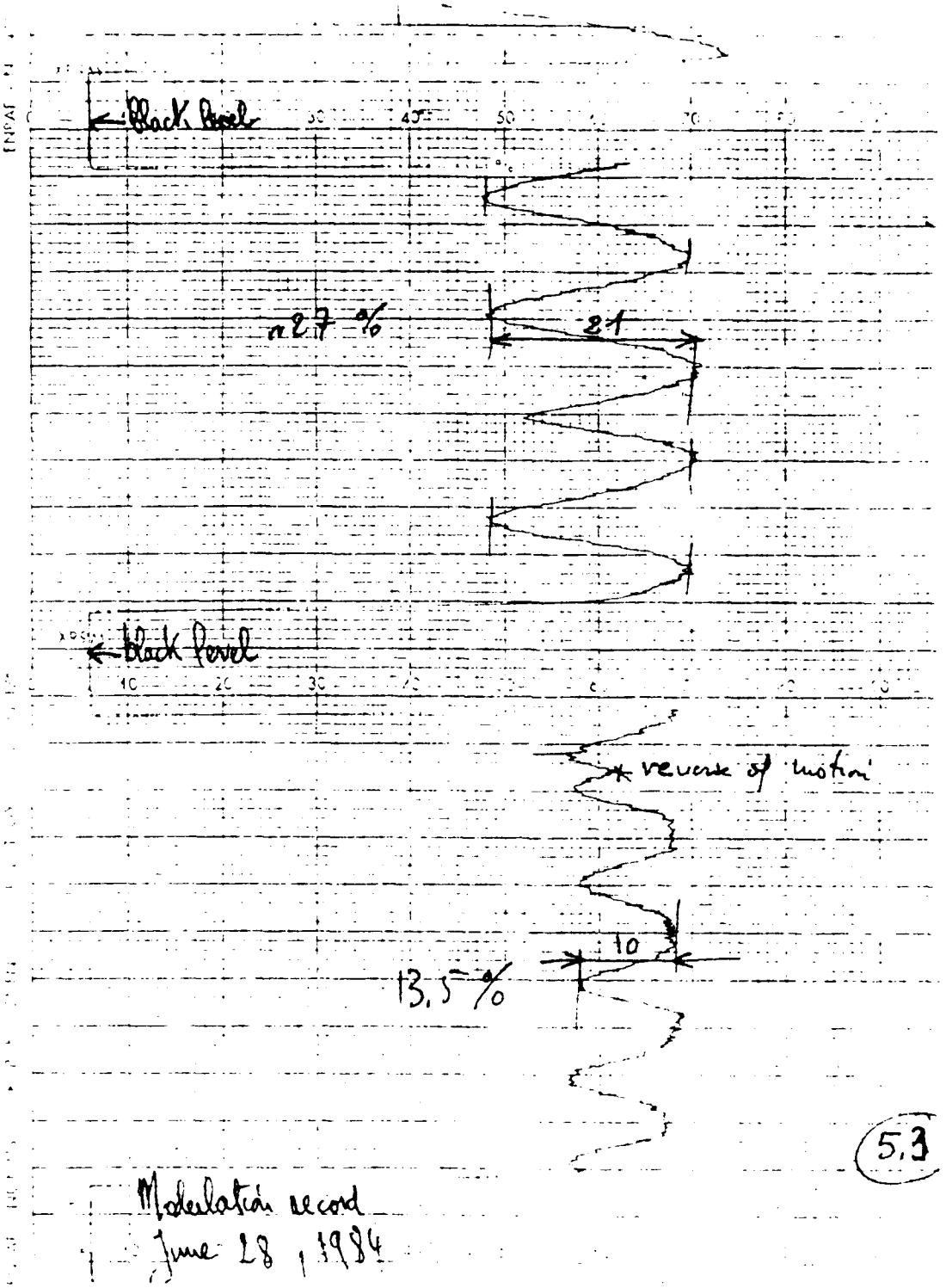
275 327 370 297 205

340 340 274

309




74
reverse of motion
black level
39
reverse of motion
5.2



5.3

Modulation record
June 28, 1984

APPENDIX B: SODERN MINUTES OF THE MEETING HELD AT WILLIAMS AFB ON 2 AUGUST 1984, DC/JRH/NC - 4063, DATED 6 AUGUST 1984

PARTICIPANTS : Cpt Jim DUFF (USAF/HRL)
Don PETRIE (GE)
Bob STONE (GE)
Ken GILBERT (GE)
Bryce ERICKSEN (GE)
Jean HURIET (SODERN)

LIEU : Williams AFB, Phoenix DATE : Aug. 2, 1984

ACTION

1. Reference documentation :

   - spec 63 A136379 rev. J (83.1.17)
   - acceptance at Sodern report DC/JRH-4052 - June 26-28, 1984

2. Installation of the SVS 14 has been made by SODERN with GE assistance. The test started August 1, 1984. The results are recorded in annexe 1 (p. 1 thru 6). The records of the modulation measurement are given in annex 2 (p. 1 thru 4).

3. Starting time after acceptance measurement are made is 462 hours at the running hourmeter.

4. The SVS 14 is accepted without waiver.

5. SODERN loan, free of charge, to the USAF an optical system which allows projection on a flat screen by opposition to the small spherical screen used with the pancake window. A set of instruction in written is given with the optics to perform the exchange.

6. Note 1 : on the red channel only a faint remnent image appears after a long static image. This is within the spec but will be investigated by SODERN and RTC. A replacement of the valve will be done if necessary at the best opportunity. No phenomenon on the blue and green channel. — SODERN

   Note 2 : SODERN is proposing a training course by the 15th of September for use and maintenance and LV replacement. Duration is 1 week cost is about 12 KU$, in which SODERN would take a share. — SODERN GE

   Note 3 : SODERN has delivered a polarizer which allows to adjust the black level for night scenes.

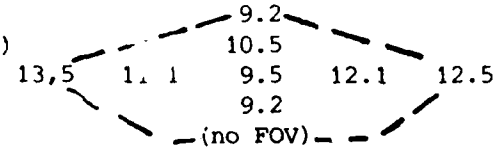
Addition to the minutes :

Note 4 : since the record of these minutes has been done SODERN has already replaced the tube of the red channel by an available spare and there is no more remnent image for any color.

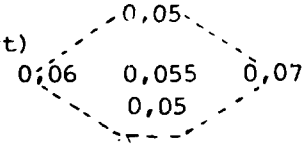
Note 5 : the starting time defined § 3 is used for the light valve guaranty. The hourmeter must be used as reference for dating any trouble that could happen.

Note 6 : non official additional measurements performed by GE and SODERN when installed with the pancake window gave the following main results measured at pilot's location :

Full white
(foot-lambert)



Full black
(foot-lambert)



Contrast W/B in the range of 150
Luminance in color spectrum (in FL)

blue 0.77 red 3.25 violet 3.02 green 5,9 cyan 7,2, yellow 10,3

Note 7 : it is necessary to measure the video signal at input before making measurement: white must be 2 volts and black 0 volt, this is in order to have the correct nominal contrast value.

RECORD COPY OF ATP TESTS AND MEASUREMENTS AT AFHRL

1-2 AUG 84

RFS 25 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
•LUMINANCE (ILLUMINANCE)	3 1 1	1950 LUMENS (129 FOOT CANDLES MEAS AT CENTER OF SCREEN)	2500L (160 FC)	2376 LUMENS (1650 LUX) MEAS ON FLAT SCREEN, X 24' RADIUS		ACCEPT	Measure with a Photometer at the virtual screen location
•LUMINANCE UNIFORMITY	3 1 2	MAX VARIATION ±15% FROM NOMINAL (MEDIAN) IN FOV	(SAME)	TESTS DONE ON 6' FLAT SCREEN 1680 (+12%) 2000 (+41%) 1650 2100 (+27%) 1240 (-45%) 2040 (+42%)		ACCEPT	Measure as above Corner 1 2 ±15% of center acceptable, due to F tangent theta lens characteristic
•CONTRAST RATIO	3.1 5	80:1 WITH FW TO FB FIELD (HW/HB 45:1 HW/BF 29 1)	100:1 (FW/FB)	FW/FB 159 HW/HB 83 HW/BF 92		ACCEPT	Measured with an input video signal (black-to-white) of 2V p-p
•GAMMA CORRECTION	3 1 17	9 LEVELS EA. 12.5% (±5%) (8 STEPS)	(SAME)	VISUAL CHECK ONLY OF VII GREY SCALE PATTERN.		ACCEPT (PRESENT GAMMA CIRCUIT AND BLACK LEVEL ADJUSTMENT PER COLOR SHOULD BE IMPROVED)	Measure without/ with lens polarizer Also measure with gamma circuit switch "OFF"
•RESOLUTION (MTF)	3 1 3	700 TV LINES (PIXELS) PER HORIZ. LINE AT 10% MTF. OFF-AXIS POINTS. ≥20 DEG, ≥8% MTF	850 P/L AT 10% MTF (OFF-AXIS ≥8% MTF)	MEASD ON-AXIS AT 700 P/L MEAS 10% MTF WITH GAMMA CORRECTION AND 5% MTF WITHOUT GAMMA CORRECTION CIRCUIT		ACCEPT	Use SODERN method of calculating from data Also, calculate % MTF = (max-min)/(max+min) x 100 H and V MTF shall be identical (Test at AFHRL may be subjective)
• FLAT FIELD	3 1 9	NO VISIBLE RASTER OR BLEMISHES (PER SPEC SHEETS 35-36)	(SAME)	VISUAL CHECK ONLY		ACCEPT (NEW GREEN W RESULTS IN A RGB PATTERN WITH NO OBJECTIONAL BLEMISHES)	Includes no visible "roof" effect at all video levels Dust particles on the lens must be removed

•INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

SODERN REPRESENTATIVE _____

GE REPRESENTATIVE _____ 8/1/84

Annex 1

P1

REF: 1-2RV676 ~~23 May 84~~

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
*BACKGROUND RASTER FOV	3.1.7.1	90 DEG CIRCULAR FOV	(SAME)	VERIFIED WITH PANCAKE WINDOW SETUP AT AFHRL		ACCEPT	Adjust H+V Size for Square Format to encompass pentagonal window
*MAPPING CORRECTION	3.1.4.1	N/A	(25% ADJ. RANGE)			N/A	Measure Adjustment Range (Will need to adjust at AFHRL with ILIOS window)
*GEOMETRIC DISTORTION	3.1.4.2	≤0.5% IN CIRCLE 80% OF IMAGE HEIGHT	≤0.25% (ETC., SAME)	DID NOT MEASURE AT AFHRL SINCE ACRYLIC SCREEN HAVE BAD COLOR FRINGES WITH SVS 14 AND PANCAKE WINDOW.		ACCEPT (SEE ATP DATA TAKEN AT SODERN) CHECK DONE ON A FLAT SCREEN AT AFHRL	Check geometric distortion at the end of image stability test (3.1.10)
*COLOR REGISTRATION	3.1.14	≤0.05% OVER A CIRCLE 80% OF FIELD. ≤0.1% OVER TOTAL FIELD	(SAME, BUT OVER ENTIRE FIELD)	SUBJECTIVELY ADJUSTED AT AFHRL FOR GOOD REGISTRATION		ACCEPT	Check color registration at the end of image stability test (3.1.10)
IMAGE STABILITY	3.1.10	≤0.5% OVER 8 HOURS	≤0.2%			ACCEPT (SEE ATP DATA TAKEN AT SODERN)	Perform a 8L stability test at the same time [illegible]
FIELD RATE	3.1.13	60 FIELDS/SEC. 2:1 INTERLACED	(SAME)			ACCEPT (SEE ATP DATA TAKEN AT SODERN)	Set VII Signal Generator for proper standards

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

SODERN REPRESENTATIVE [signature]

GE REPRESENTATIVE [signature] 8/2/84

A1 P

CHECKLIST SUMMARY FOR BVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
REPOSITIONING (BLANKING)	3 1 8	VERT BLANKING ≤619 usec HORIZ BLANKING ≤7 usec	(SAME)			ACCEPT (SEE ATP DATA TAKEN AT SODERN)	Set VII Signal Generator for proper standards
•DISPLAY TIME RESPONSE (LATENT IMAGE)	3 1 6	PER SPEC: 40% AFTER 1 FRAME, 10% AFTER 2 FRAMES, 1% AFTER 3 FRAMES, 0.3% AFTER 4 FRAMES, (OVERWRITE AFTER 5 MIN OF STATIC SCENE)	(SAME)	SUBJECTIVE TEST ONLY AT AFHRL		ACCEPT (SEE ATP DATA TAKEN AT SODERN.	Check with/without Orbiter switch on (Subjective test only at AFHRL)
OPTICAL SYSTEM AND PROJECTION LENS	3.1.18	90 DEG. FOV. 24 IN. RADIUS SCREEN, EXIT PUPIL WITHIN ±0.25 IN OF COC THROUGHOUT FIELD	(SAME)			ACCEPT (VERIFIED AT SODERN)	Check Swivelling Range of Projection Lens Do at SODERN
•ELECTRICAL INTERFACE	3.2.1	208V, 60 Hz, 1 PHASE, (TBD)KW 208V, 60 Hz, 3 PHASE, (TBD)KW	(SAME)	NO PROBLEMS WHEN OPERATED ON U.S. PRIMARY POWER		ACCEPT	Test at SODERN on 220/380V, 50 Hz Measure power required Verify performance on 208V, 60Hz at at AFHRL
MECHANICAL INTERFACE	3 2 2	PROJ. VOL <0.37 cubic meter PROJ. SIZE <95 x 70 x 55 cm PROJ. WEIGHT <136 kg WITHOUT 110 kg COOLING SYSTEM (<150 WITH)	(SAME except 110 kg total weight)			ACCEPT (VERIFIED AT SODERN)	Reference applicable SODERN report

•INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

SODERN REPRESENTATIVE R. Jayard

GE REPRESENTATIVE R. J. Adams 8/2/84

A1 P:

REF 23 May 84

CHECKLIST SUMMARY FOR SVS-14 SODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
*OPTICAL INTERFACE	3.2.3			OPTICALLY ALIGNED SVS-14 WITH PANCAKE WINDOW USING GRADE 5 POLYCARBONATE (CLEAR) SCREEN		ACCEPT	Initially with an Off-Platform Window at AFHRL
*DATA (SIGNAL) INTERFACE	3.2.4					ACCEPT (VERIFIED AT SODERN AND AT AFHRL)	Check Individual H+V Sync Drive and Comp H+V Drive
EMI AND SUSCEPTIBILITY	3.3.2			N/A	ANALYSIS REVIEWED	ACCEPT	Define design/ analysis done on EMI
COOLING REQUIREMENTS, ENVIRONMENTAL REQUIREMENTS	3.3.4 3.8	OPERATING TEMP. RANGE (+15 TO +25 DEG C) HUMIDITY 0-90% NON-CONDENSING	+15 DEG TO +38 DEG C (OTHERWISE SAME)	N/A	DATA AND ANALYSIS REVIEWED	ACCEPT	Report results of Thermal Model Tests at SODERN
RELIABILITY	3.4			N/A	ANALYSIS REVIEWED	ACCEPT	600-800 Hrs MTBF per SODERN calc SODERN CALCULATE: 1100 HRS MTBF AT GROUND ENVIRONMENT
FAILURE ANALYSIS	3.4.1			N/A	ANALYSIS REVIEWED	ACCEPT	Define analysis done, if any

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

SODERN REPRESENTATIVE _____

GE REPRESENTATIVE _____ 8/2/84

1-3 AUG 84
RFS ~~28 May 84~~

CHECKLIST SUMMARY FOR GVS-14 BODERN PROJECTOR TESTING

ITEM	SPEC REF	MIN	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
MAINTAINABILITY	3 5			N/A	ANALYSIS REVIEWED	ACCEPT	Discussion of Method of Replacing LVs at Site and Spares MTTR CALCULATION IS 43 MIN. (SPEC IS 60 MIN.)
SAFETY	3 6			N/A	ANALYSIS REVIEWED	ACCEPT	Discuss safety aspects Eye damage and X-rays from Xenon Arc? (NO X-RAY PROBLEMS. CARE TO BE TAKEN IN CHANGING XENON ARC)

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

A1,P

1-2 Aug 84
RFS 23 May 84

CHECKLIST SUMMARY FOR SV8-14 SODERN PROJECTOR TESTING (FOR INFORMATION ONLY)

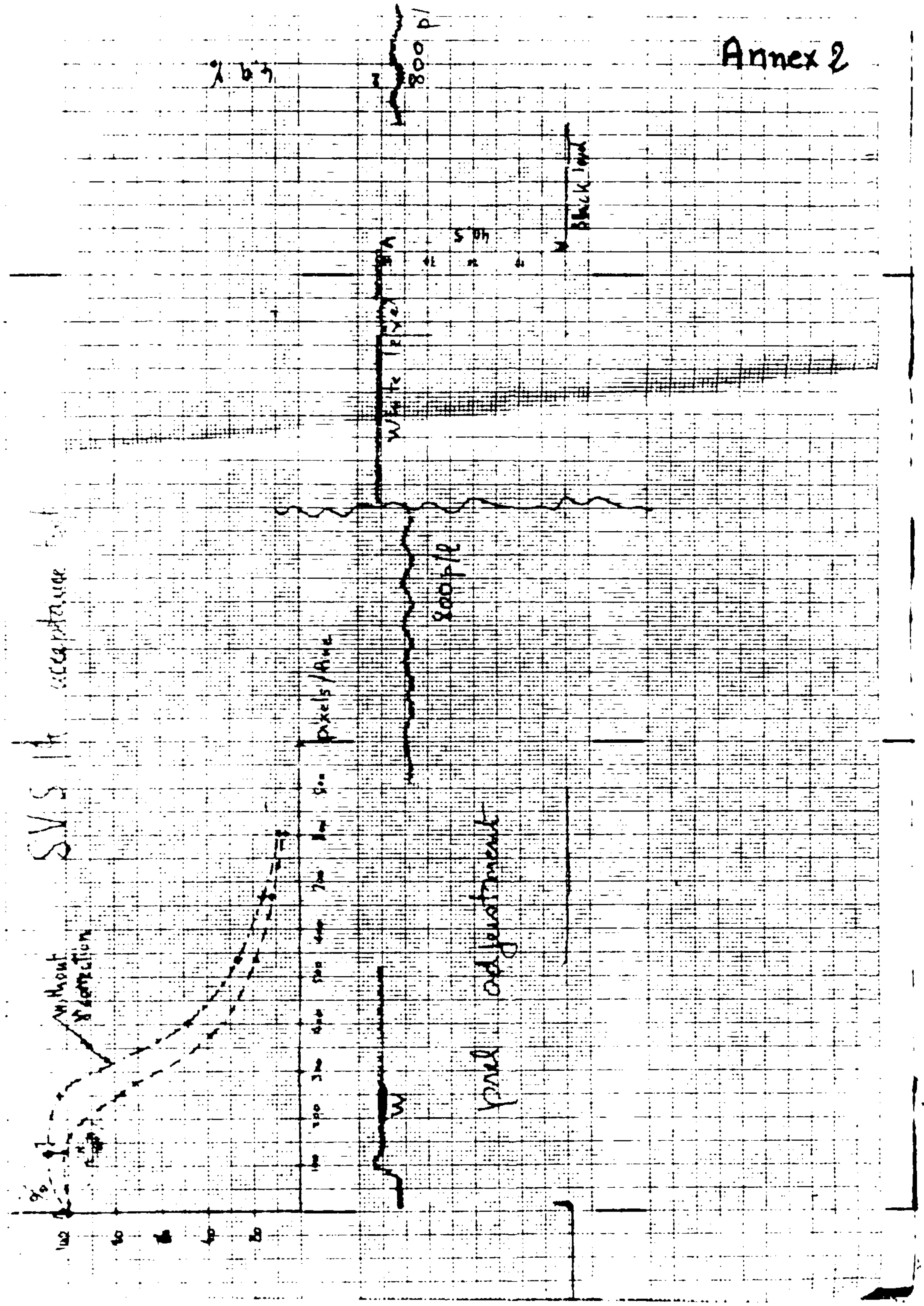
ITEM	SPEC REF.	MIN.	GOAL	ATP TEST	REVIEW TEST DATA/ANALYSIS	ACCEPT/REJECT	ACTION/REMARKS
BLACK LEVEL STABILITY	3 1 16	N/A	N/A	N/A	N/A	N/A	Recommend a Test Measurement--for Information
*MIN. BLACK LEVEL (NIGHT SCENE)		N/A	N/A	N/A	N/A	N/A	Recommend a Test Measurement--for Information Combine with image stability test
*PROJECTED IMAGE ON A FLAT SCREEN		N/A	N/A	N/A	N/A	N/A TESTS WITH VII SIGGEN. DONE AT AFHRL ALSO.	For demo only at AFHRL (Use of another Projection Lens)
*DYNAMIC IQ SCENE PERFORMANCE		N/A	N/A	N/A	N/A	N/A	Subjective evaluation of a full color dynamic IQ scene at AFHRL, thru a window and on a screen, for demo only.
DYNAMIC VIDEO DISC TESTS MADE ON 625 LINES, 25 FRAMES SEEN AT SODERN						N/A TESTS DONE AT SODERN ONLY.	Useful subjective data on image smear versus LV beam current (approx 50 u amp rather than previously used 70 u amp appears OK)

*INDICATES TEST TO BE REPEATED AT AFHRL, PERHAPS IN A MODIFIED FORM

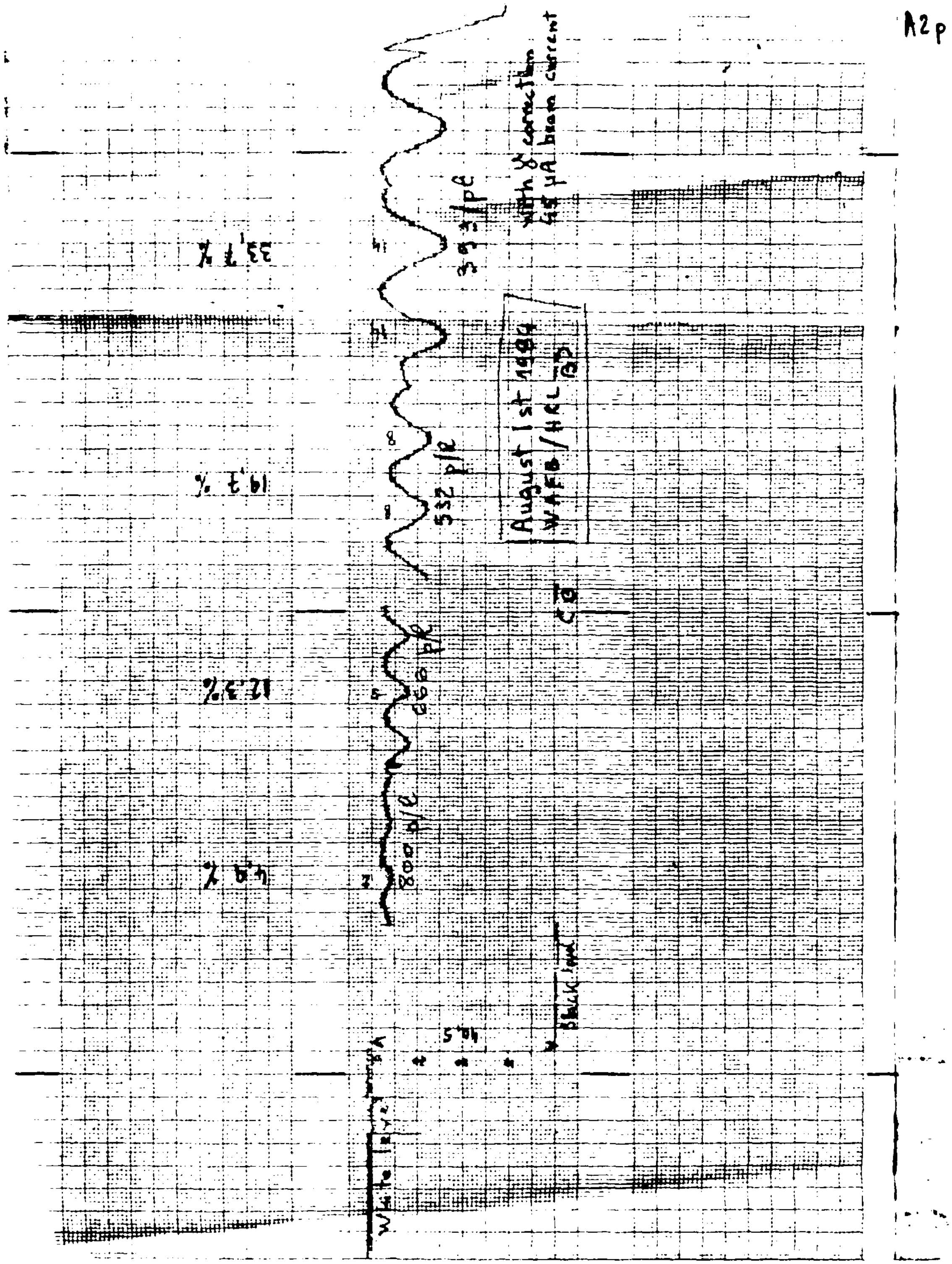
SODERN REPRESENTATIVE _____

GE REPRESENTATIVE _____

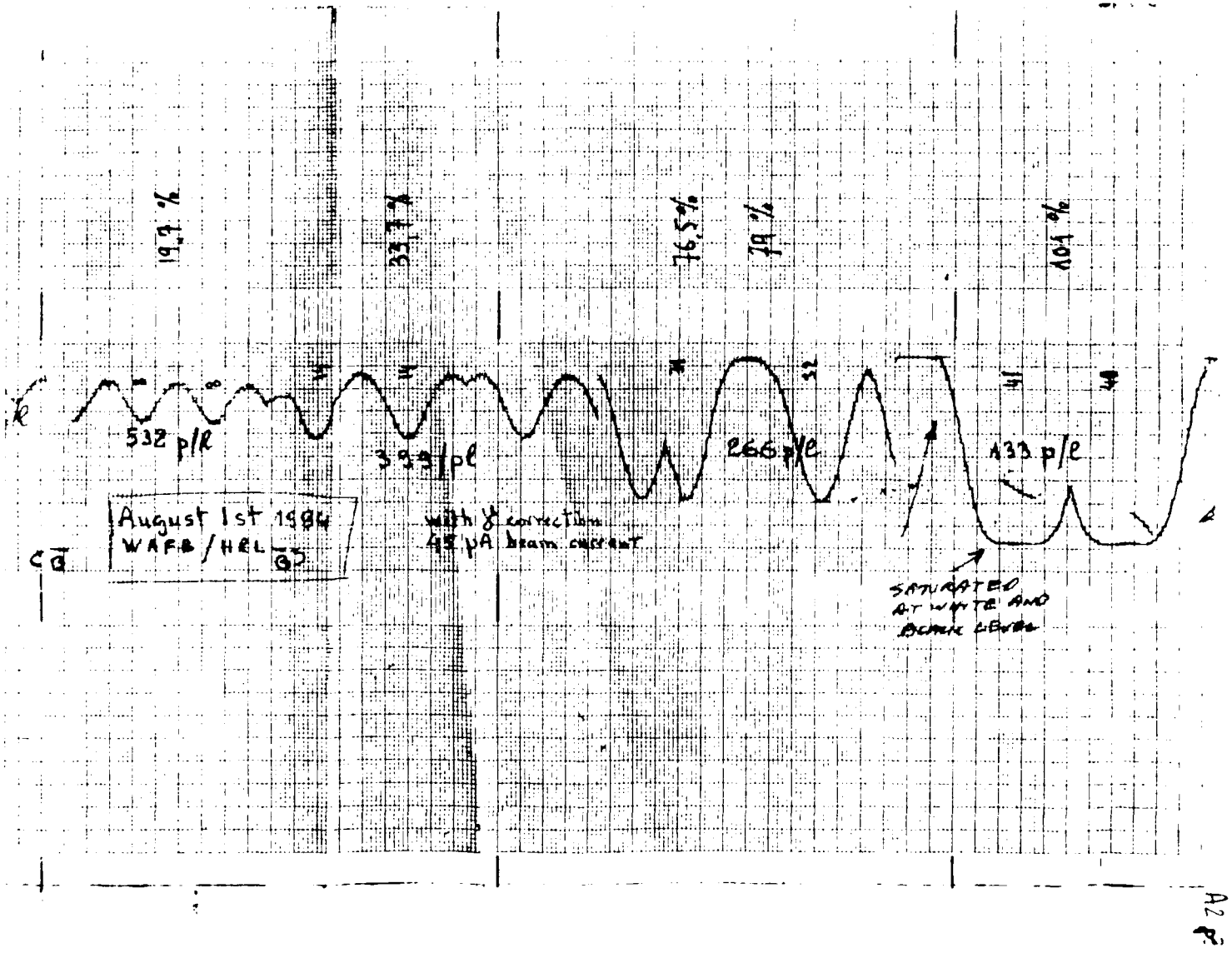
Annex 2

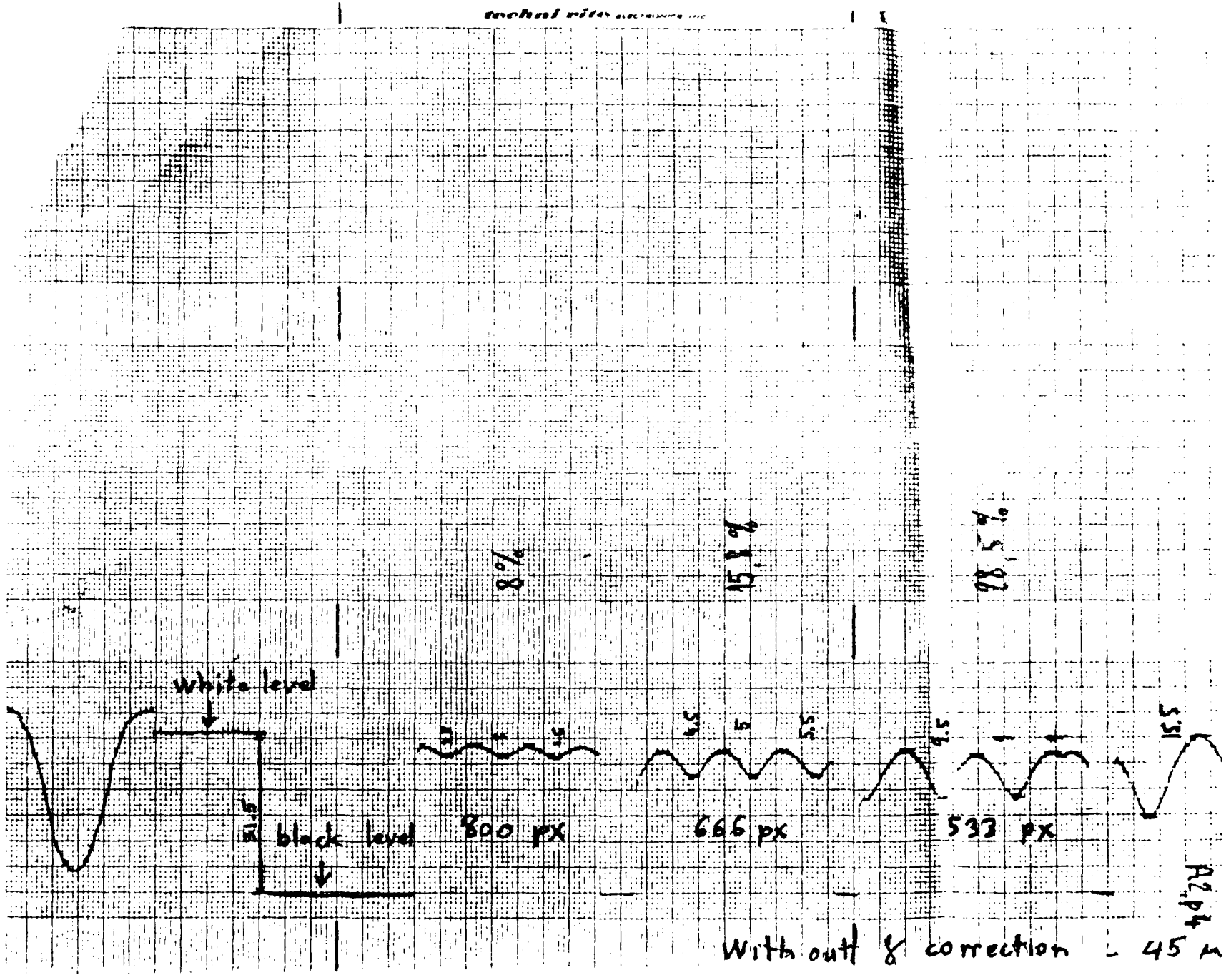

pixels/line
pixel adjustment
Black level
without distortion

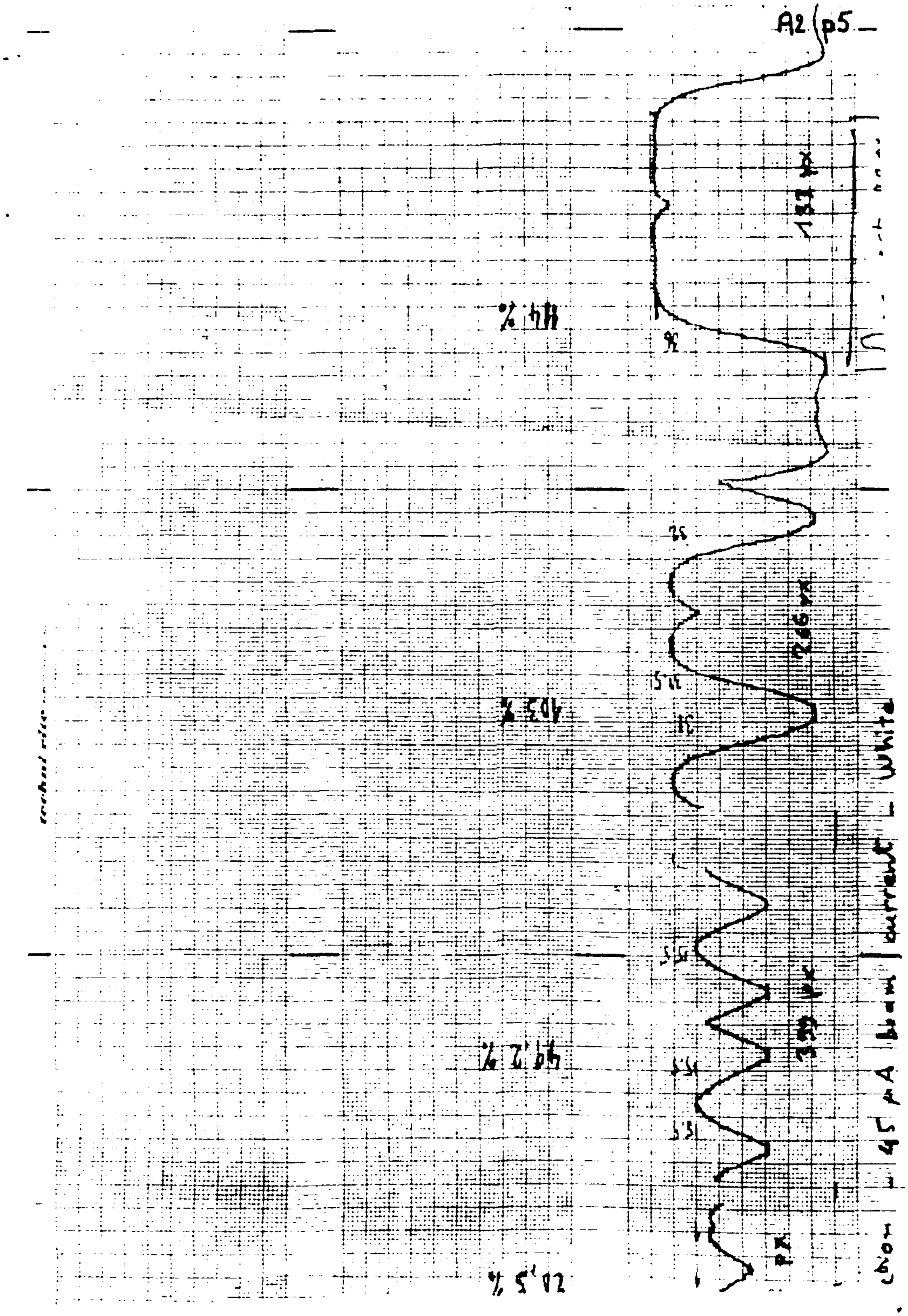
A2p



White level
Black level
10.5
4.9 %
12.3 %
19.3 %
33.7 %
800 p/l
660 p/l
532 p/l
393 p/l
August 1st 1984
WAFB/HRL
with γ correction
45 μA beam current


19.9 %
33.3 %
76.5 %
99 %
101 %
532 p/R
399 p/e
266 p/e
133 p/e
August 1st 1984
WAFR / HEL
with γ corrections
45 μA beam current
SATURATED AT WHITE AND BLACK LEVELS


white level
black level
800 px
666 px
533 px
With out γ correction - 45 m


A2 p5

APPENDIX C: UDRI MEMORANDUM DATED 29 OCTOBER 1984

UNIVERSITY OF DAYTON

RESEARCH INSTITUTE

P.O. BOX 44
HIGLEY, ARIZONA 85236

MEMORANDUM 29 Oct 1984

TO: Capt. James M. Duff, Program Manager AVTS

FROM: Peter Crane, Ph.D., Research Psychologist, UDRI

RE: Visual comparison of Sodern SVS-14 and General Electric PJ5155 light valve projectors.

As part of a side-by-side comparison of the SVS-14 and PJ5155 light valve projectors conducted at AFHRL/OT, Williams AFB on 18 October 1984, I asked several participants to rate the visual appearance of the two systems. These evaluations were conducted by feeding video test patterns and AVTS imagery to both light valves; scenes were projected simultaneously to adjacent rear projection screens. Respondents were therefore able to view both systems while making comparisons. A rating form was constructed for this test in consultation with Herb Bell of AFHRL/OTP and Bob Stone from General Electric. On this form, respondents were asked to judge which projector was superior on a variety of items; a copy of the form is attached. Finally, raters were asked to state their overall evaluation of the projectors and the reasons for their judgment.

Completed forms were returned by five individuals: three from Singer-Link and two from AFASD/ENETV. All five listed flight simulator visual systems as their primary application for light valve projectors. Their responses to the questionnaire are summarized in Table 1.

The item "grain, raster, and artifacts" elicited some comment. One rater said that the GE showed a visible raster structure. Four raters said that the Sodern displayed a "starburst" effect near high contrast edges and that this effect was quite annoying. The Sodern was also judged to have a perceptible lag on persistence behind moving edges.

All five judges rated the GE PJ5155 superior to the Sodern SYS-14. Their reasons included better contrast, sharper images, and less persistence. Two respondents rated PJ5155 as A--Excellent, two rated it between A--Excellent and B--Acceptable, and one assigned it a rating of B.

TABLE 1
SUMMARY OF COMPARISONS OF SODERN SVS-14 AND
GENERAL ELECTRIC PJ5155 LIGHT VALVE PROJECTORS (n=5)

GE SYSTEM IS SUPERIOR TO SODERN	THE TWO SYSTEMS ARE NEARLY EQUIVALENT	SODERN SYSTEM IS SUPERIOR TO GE
G	E	S

(NR = No Response)

QUESTION	DYNAMIC IMAGES		STATIC IMAGES		TEST PATTERNS
	DAY SCENES	NIGHT SCENES	DAY SCENES	NIGHT SCENES	
1. Brighter	GE 0 E 3 S 2	GE 0 E 3 S 2	GE 0 E 3 S 2	GE 0 E 3 S 2	GE 0 E 3 S 2
2. Sharper: Center	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0
Corners	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0	GE 5 E 0 S 0
3. Contrast	GE 3 S 0 E1 (NR1)	GE 4 S 0 E0 (NR1)	GE 3 S 0 E1 (NR1)	GE 4 S 0 E0 (NR1)	GE 5 S 0 E0
4. Color Saturation	XX	XX	XX	XX	GE 0 S 0 E 3 (NR2)
5. Hue Accuracy	XX	XX	XX	XX	GE 0 E 2 S 1 (NR2)
6. Color Registration	XX	XX	XX	XX	GE 5 E 0 S 0
7. Grain, Raster, Artifacts	GE 2 S 0 E2 (NR1)	GE 2 S 0 E2 (NR1)	GE 2 S 0 E2 (NR1)	GE 2 S 0 E2 (NR1)	GE 2 S 0 E2 (NR1)
8. Less Persistence	GE 5 S 0 E 0	GE 5 S 0 E 0	XX	XX	XX
9. Smoother Motion	GE 2 S 0 E 3	GE 2 S 0 E 3	XX	XX	XX

NAME _____

ORGANIZATION _____

COMPARISON OF GE AND SODERN LIGHT VALVE PROTECTORS
AFHRL/OT, WILLIAMS AFB, 18 OCTOBER 1984

Use the questions on the facing page to compare the two systems. Enter the appropriate letter from the scale below to indicate your judgment. Please record any comments or observationsalong with your rating.

GE SYSTEM IS SUPERIOR TO SODERN — THE TWO SYSTEMS ARE NEARLY EQUIVALENT — SODERN SYSTEM IS SUPERIOR TO GE

G — E — S

QUESTION	DYNAMIC IMAGES		STATIC IMAGES		TEST PATTERNS
	DAY SCENES	NIGHT SCENES	DAY SCENES	NIGHT SCENES	
1. Brighter					
2. Sharper: Center					
Corners					
3. Contrast					
4. Color Saturation	XX	XX	XX	XX	
5. Hue Accuracy	XX	XX	XX	XX	
6. Color Registration	XX	XX	XX	XX	
7. Grain, Raster, Artifacts					
8. Less Persistence			XX	XX	XX
9. Smoother Motion			XX	XX	XX

(CONTINUED ON REVERSE)

QUESTIONS FOR GE -- SODERN LIGHT VALVE PROJECTOR COMPARISON

1. Which system has a brighter image?

2. Which system has a sharper image --

   In the Center of the screen?

   In the Corners of the screen?

3. Which system has more contrast between light and dark areas?

4. Which has more saturated colors?

5. In which system are the hues more accurate?

6. Which system has better color registration?

7. Which system shows less grain, raster, or visable artifacts?

8. When an image moves, which system shows less persistence? i.e. Does the trailing edge of a moving object seem to lag behind or leave a shadow for a brief time? (Better means less persistence or lag)

9. Which system shows smoother or less jerky movement?

APPENDIX D: SOD[illegible]N LETTER DC/JRH/ET-2145 DATED 8 NOVEMBER 1984

U.S. AIR FORCE
Human Resources Laboratory
Williams Air Force Base
PHOENIX
Arizona 85224
U.S.A.

Attn : Captain James DUFF

Dear Jim,

According to our phone call last week I send you here enclosed my comments about the unexpected situation which we had to live with during the demonstration. I hope it is now working correctly again and anyway after what I saw I would appreciate to have the opportunity to make a test again for example before, during or after the training course at Human Research Laboratory.

I have seen for the first time during the demonstration the kind of images the computer is able to deliver and I feel it would be of interest to look at them again at Sodern's convenience in order to determine how to optimize the SVS adjustment for your needs.

I understood from Mr Ed Herd that the date for the course is already agreed to be 2 thru 7 of december. It could happen we bring again a new valve, just for test.

I would appreciate also to have a discussion with you and Dr Bell about the evaluation program because it could lead to modify SVS adjustment. We already do not know exactly what is most valuable for you but the contract spec. I have the feeling we can optimize better.

Very truly yours.

Jean R. HURIET
Marketing Manager
for North America

SVS - SODERN VISUALIZATION SYSTEM AS PER OCTOBER 19TH DEMONSTRATION

1 - ELECTRONICS

Sodern has been informed a week before the demonstration that there was a loss of focusing and a red light "on" indicating a failure in the 60 volts circuitry. They came with spare parts in a luggage which was unfortunately lost by the air carrier.

Therefore the only possibility was to make a try with the SVS as available and eventually use only the green channel which seemed to be correct when used alone. After a first test Sodern decided to replace the green channel light valve by a new laboratory valve available, in order to verify in absence of electronics spares if it was the light valve or the electronics which was failing. The test have been made during all afternoon with the single green channel light valve except for the last minutes when the blue and red channels have been switched on in order to see a full color image.

2 - LIGHT VALVE

The light valves, ordinary SV2 square target ones, are typically used with 45-50μA beam current for fast motion. The laboratory light valve (Nr 65) is a prototype with rectangular target and a new grid. By comparison with the SV2 technological improvements have been made. One relates to the grid the winding pitch of which is 35 x 35μm instead of 50 x 100μm. Therefore the grid transparency to electrons is reduced by about 20 %. The overscanning due to the square format by comparison with the 3 x 4 format leads to another 25 % loss in electron efficiency.

The maximum beam current obtained with the laboratory model is 70μA which in the condition of the demonstration would correspond to 35-40μA with the SV2. The result was a visible lag and tailing during fast motion. The SV2 can be used with up to 90μA. A new fast motion test will be performed when the SV2's are used on the 3 channels.

But the Nr 65 light valve although it is not made for fast motion allowed to demonstrate 10 % modulation at 930 pixels/line and 1 080 p/l at about 5 %. When used in laboratory with a low beam current ($<$10μA), the limit of visibility extends up to 1 200 p/l.

3 - CONTRAST

The SVS 14 delivered to HRL is normally equipped with 90 arc degree circular FOV optics suitable for the pancake window. These optics include a field stop and allow to reach a very high contrast ratio. During acceptance test the measurement gave 150 between full white/full black image and 92 with a 1/4 white window over a black background (Incidently Sodern pointed out that the white window over the black background is the only way to obtain true operational value of together black level value, contrast and luminous output because that is a unique situation where all parameters must be set together).

These nominal optics allow to display onto a spherical screen with a F tangent θ law. The optics used for the demonstration belongs to the previous prototype and where to be used only for some tests. These optics have no field stop and where not limiting the circular FOV. The immediate result, as expected, is a loss in contrast which was measured only 45, as for General Electric.

An other effect is a loss in focusing because these optics had been designed for a 15 to 20 meters throw distance (large screen) and were used with about 3m throw distance on a $1m^2$ screen.

4 - BRIGHTNESS UNIFORMITY

An other effect of the use of the previous optics is that they project with a F.θ law. Therefore the uniformity in the field is completely destroyed. The F. tangent θ law leads to 100 % brightness at center and 125 % at the edge but when used with F.O law this gives 100 % at center and 50 % at the edge. When adjusted for F.θ law the SVS may give more than 60 % at corners and more than 70-75 % at the edge. This is obtained by special in plant adjustment of the illumination subassembly. Anyway the brightness at center being the same in both cases the high luminous output has been demonstrated (2.5 times G.E., for both projectors the flux in lumens is obtained by the multiplication of illumination at center by screen area).

Note :

The light valve Nr 65 was not brought to perform the demonstration but only to demonstrate the capability to extend the resolution up to 1 500 p/l with the same target size, by means of new development and improvement proposed by Sodern.

APPENDIX E: SODERN REPORT DC/JRH/ET-2492 DATED 8 DECEMBER 1984

US AIR FORCE
HUMAN RESOURCES LABORATORY
Williams AFB
Arizona 85224
USA

Attn : Mr Peter GERLICHER

Dear Peter,

I am pleased to send you here enclosed the typed version of the report we reviewed together before I left. You have been informed by MM. Monod and Plaisant that the dynamic focussing of the SVS 14 has not been completely fixed but we are planning to come again before the test planned by your laboratory in January.

We are learning what means computer generated images by comparison with the test patterns or with live TV and hope to make soon some progress in that field. We hope that the cooperation with HRL will lead to something satisfactory for the pilots and as you have certainly noticed we are prepared to work hard on this way.

Very truly yours.

Jean R. HURIET
Marketing Manager
for North America

Enclosure : 1 report (2 ex)

December 1984

COMPARISON TEST BETWEEN SVS 14 AND GE 5155

. The tests were performed at the Human Resources Laboratory/ Williams AFB with a side by side display of the images given by both General Electric and Sodern projectors.

. The screen being only $1m^2$ was inadequate to perform other test than appreciation of the blur during fast motion. All other parameters such as contrast or illumination level cannot be estimated correctly by the human eye during the conditions of over illumination. Therefore the purpose was limited to :

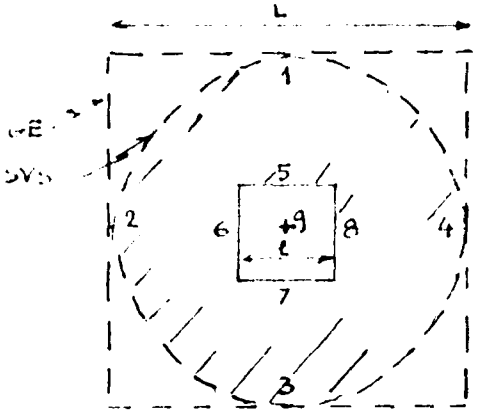
- measure the contrast with two reversed conditions (W/B and B/W)
- measure the black uniformity and the white uniformity
- measure the luminous output at field center
- estimate the resolution capability
- estimate if the blur due to fast motion was acceptable.

. The test was performed on december 4th in the presence of 9 trainees, attending the training course for the maintenance of the SVS 14, this test was also witnessed by Mr R. [illegible]ltmacher and Cpt J. Duff (USAF/HRL). The test has been performed also on december 6th and witnessed by Mr B. Goldiez (PM Trade) and Mr P. Gerlicher (HRL).

. Most of the test performed on October 19, 1984 has no value because the SVS was out of normal operation at this time.

- USAF : 4 copies
- US Army : 2 copies
- GE : 1 copy
- University of Dayton : 2 copies
- Sodern : 1 copy

1) Measurements and results with a white window over a black background



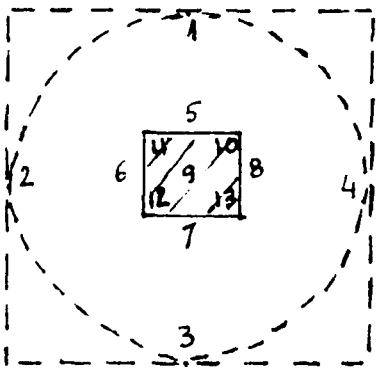
- All measurements are in lux ie in lumen/m^2
- 1 lux $\simeq$ 0.09 foot-candle
- Lengths are measured in meters
- in $\simeq$ 40 inch
- The flux Φ (luminous output) is conventionnally obtained by the illuminance at center times the area of the screen in square meter.

Note : The SVS has been built according to specification (circular FOV) and especially for display thru a pancake window and for the use of a lens having a F.tan θ law on a spherical screen. This corresponds to a correction factor of about 1.3 at the edge of the screen between the measured illuminance and the effective illuminance. The measurements results are given without correction, the computed uniformity is given with correction in 1, 2, 3 and 4 whatever it is white or black.

Spot nr	SVS 14			GE		
	measured	average	uniformity	measured	average	uniformity
1 2 3 4	15 13 14 14	14 x 1.3 = 18	7 %	11 9 7 16	11	40 %
5 6 7 8	41 42 40 33	38	12 %	14 12 10 13	12	17 %
9	1710			633		
Φ (lm)		1838*			698	
C1		95			58	
C2		45			53	
L l	1.17 0.30			1.05 0.26		

* if the useful area was square the flux would be 2 340 lumens

2) Measurements and results with a black window over a white field



. Same comments as per § 1

. Measurements in 10, 11, 12 and 13 added in order to evaluate the black level uniformity.

Spot nr	SVS 14			GE 5155		
	measured	average	Uniformity	measured	average	uniformity
1	860			458		
2	790		9.2 %	530	538	14.8 %
3	920	871		615		
4	915	x 1.3 = 1132		550		
5	1 450			613		
6	1 440	1 477	3.6 %	648	634	3.3 %
7	1 490			652		
8	1 530			622		
9	63			14		
10	71			16		
11	74	71.2	11.5 %	20	17.8	21 %
12	75			19		
13	73			20		
C1		15.9			30	
C2		20.7			35.6	

. C1 : contrast between average (1, 2, 3, 4) and average (9, 10, 11, 12, 13)

. C2 : contrast between average (5, 6, 7, 8) and average (9, 10, 11, 12, 13)

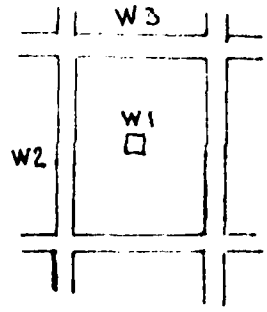
. Center to edge illumination uniformity :

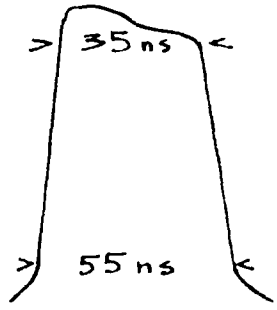
SVS 1 710 — 1 477 — 1132 total : 66 %
(86 % / 76 %)

GE 633 — 634 — 538 total : 84 %
(100 % / 84 %)

3) Measurement of the line and pixel width

- The test pattern generator delivers a cross-hatch pattern with a single white spot at center :
  W1 is the width of the spot
  W2 is the width of the vertical line
  W3 is the width of the horizontal line
- The video signal at the generator output measured with a scope is as represented aside. The half amplitude width is 45 nanosecond
- The scanning line duration is 32.6 μs but the useful duration is 25.5 μs. Therefore with 1 000 pixels/line, the duration is about 25 ns
- The pulse width corresponds to 1.8 pixels and the equivalent spatial frequency (ESF) in terms of resolution is 555 pixels per line
- The vertical line width is the same as for the pulse
- The horizontal line is made of 2 interlaced lines, therefore the equivalent spatial frequency is 500 p/l.





	SVS 14		GE 5155		Test pattern ESF
	measured	ESF	measured	ESF	
W1	2mm	585	4mm	262	555
W2	3mm	390	5mm	210	555
W3	4mm	292	5mm	210	500

. L = 1 170mm for SVS 14
. L = 1 050mm for GE 5155

. measured ESF = L/W

Note : width measurement accuracy $\pm$ 0.5mm gives $\pm$ 30 pixels/line average error on the measured ESF.

Comments :

The brightness of the central spot displayed by the projectors must be according to the modulation obtained with the corresponding ESF. If the projectors were perfect the modulation would be the one obtained at 555 p/l ie about 40 %.

The GE 5155 works with an ESF of 262 p/l ; therefore, the modulation is close to 80 - 100 %. The spot is very bright, but does not respect the geometry.

The SVS 14 works with an ESF of 585 p/l ; therefore, the modulation cannot be greater than 40 % of the maximum brightness. In fact the amplitude is lower due to erasing during interlace. This explains also why the spot seems smaller than generated.

The use of electronics tricks could give a brighter spot with the SVS 14 but at the detriment of the geometry.

Experiments will help to determine if it is better to have resolution rather than brightness for the pilot. The fact that the wider GE spot has not been a drawback up to now may indicate that the brightness is more of interest than geometry. It seems that the sharpness of the transition at the edges with the GE 5155 gives the illusion of high resolution more than the smooth transition obtained with the SVS 14. What is more convenient ?

4) Fast motion test

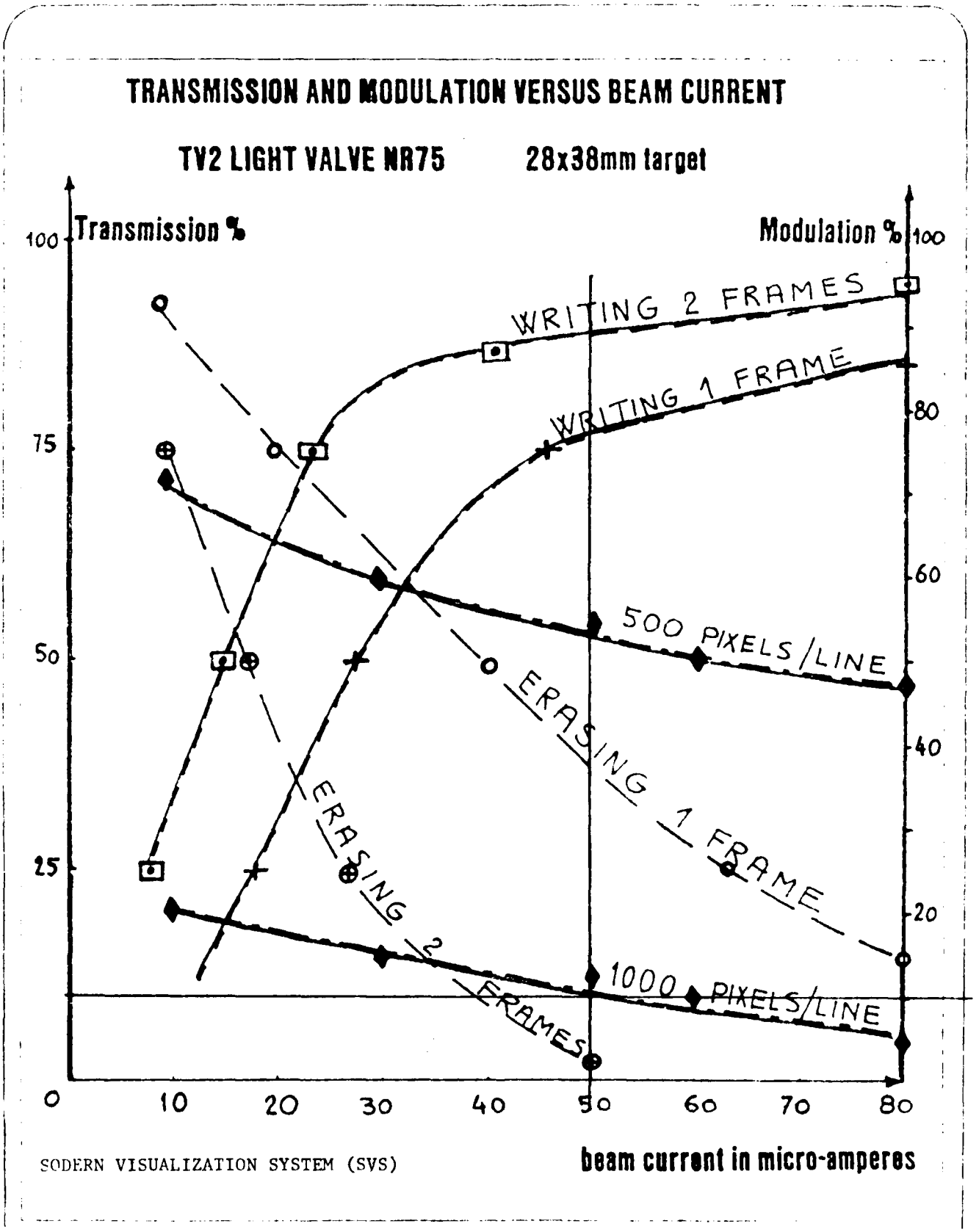
On December 4th it was not possible to obtain a computer generated image. In order to have a similar motion the test pattern generator was used with a small white square at the center and this square was moved at different speeds and with different beam currents for the SVS 14.

A first test of this kind was performed in October 84 ; but, at this time the SVS 14 was not repaired (the failure occurred a few days before the test). The defective light valve was not able to deliver a sufficient beam current even though it was inside the specified limit. A new light valve has been installed in the SVS 14 before the december 4th test. It allows us to obtain up to 120 μA when the previous one was only capable of 50 μA. The light valves on the red and blue channels cannot deliver more than 75 μA.

The curves given on the next page show the influence of the beam current on the writing and erasing capability (expressed as a transmission factor) and also on the modulation for a given number of pixels per line (500 and 1 000). These curves have been measured with a rectangular target light valve (TV 2) and can be used in first approximation for the square target light valves (SV 2).

The specification of the SVS 14 was to write/erase within two frames. This can be achieved with 50 μA and gives a modulation of about 10 % at 1 000 p/l at light valve level. The resolution test performed with this beam current value (50 μA) for all of the 3 light valves gave a readability of the seventh bar of the test pattern ie 130 x 7 = 910 p/l which is in good agreement with the chart. For this beam current value the fast motion of the white square gave (as seen during the 18 october test) a significant blur.

The resolution and the blur have also been evaluated visually for 80 μA and for 120 μA. For this last value the visual effect and the resolution were seen as being about same for the GE 5155 and the SVS 14. The resolution of the SVS 14 being about the same for 80 and for 120 μA it has been decided to leave the SVS 14 with 120 μA on the green channel and 75 μA on the red and blue channels. The 5th resolution bar is visible in black and white with these values of beam current ie 650 p/l, the 6th bar was visible only at the center.


TRANSMISSION AND MODULATION VERSUS BEAM CURRENT
TV2 LIGHT VALVE NR75
28x38mm target
Transmission %
Modulation %
100
75
50
25
0
100
80
60
40
20
WRITING 2 FRAMES
WRITING 1 FRAME
500 PIXELS/LINE
ERASING 1 FRAME
ERASING 2 FRAMES
1000 PIXELS/LINE
10
20
30
40
50
60
70
80
beam current in micro-amperes
SODERN VISUALIZATION SYSTEM (SVS)

Conclusion

- The SVS 14 gives about 2.5 times more luminous output
- The contrast between a white window and a black background is approximately the same for both projectors
- The contrast between a black window and a white background is better with the GE 5155
- The uniformity of the black background is better with the SVS 14
- The uniformity of the white background level is about the same for both projectors
- The SVS 14 displays more accurately the size of small objects but with less brightness. A trade off between brightness and resolution must be determined on this matter by the user.
- With the high beam current in the SVS 14 light valve the fast motion gives in a very first approach, the same kind of visual effect as for the GE 5155. Experiments are needed to determine if this is confirmed or not by the pilots.
- The sharpness of the image looks better with the GE 5155 when the image is delivered by the computer; further tests are necessary to determine why, because the static resolution is about the same.

END

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